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20 February 1986

China Report

SCIENCE AND TECHNOLOGY

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20 February 1986

CHINA REPORT

SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

LI PENG ADDRESSES BEIJING MEETING ON TECHNOLOGY

OW190622 Beijing XINHUA Domestic Service in Chinese 1650 GMT 18 Jan 86

[Text] Beijing, 18 Jan (XINHUA)--Speaking at a Beijing-area work conference on the application of electronics and information technology which ended today, Li Peng, vice premier of the State Council, said: In employing microcomputers, it is necessary to implement the principle of accomplishing more with less money, and it is also necessary to promote development by means of application.

Li Peng said: In electronics and information technology, Beijing has a great advantage because it has a concentration of one-fourth of the nation's technological personnel. But in the past Beijing failed to make the best use of this advantage and was hindered by the ownership system of various departments and areas. If everyone wants to establish a relatively complete system of one's own, it would be very difficult to unite the individual forces. Now, at the suggestion of the Beijing Municipal CPC Committee and government and with the approval of the Leading Group for Revitalizing the Electronics Industry of the State Council, a Beijing Municipal Leading group for Revitalizing the Electronics Industry has been established. If the group succeeds in organizing Beijing's forces, formulates overall planning, carries out the proper division of labor, unites, and cooperates it will surely be able to implement the principle of accomplishing more with less money, and it will achieve good results. The participation in the today's meeting by the leading persons from the various ministries and commission of the central organs showed that they support an alliance among Beijing's electronics professions and trades.

Li Peng also pointed out that in applying electronics technology, the various units must be pragmatic in suiting their own conditions and should not chase after the most advanced equipment and most sophisticated technology. China is already capable of producing some types of microcomputers. We must use our own products as much as possible.

Li Peng again stressed that in revitalizing the electronics industry, it is necessary to promote development by means of application. He pointed out that the ultimate goal of introducing, digesting, developing, and pioneering electronics technology is to produce our own microcomputers by relying on our own strength. This is the only way to popularize and spread electronics technology and achieve good results. He hoped that Beijing will make a good start in developing electronics products of the means of production and consumer types and in the application of electronics technology.

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CSO: 4008/1035

NATIONAL DEVELOPMENTS

RENMIN RIBAO ON WORK OF SCIENCE FUND ACADEMY OF SCIENCES

HK071300 Beijing RENMIN RIBAO in Chinese 28 Dec 85 p 1

[Report by correspondent Chen Zujia [7115 4371 3966]: "The Chinese Academy of Sciences Scores Remarkable Results in Setting Up Science Funds"]

[Excerpts] Over the last 4 years since the Science Fund was set up by the Chinese Academy of Sciences with a view to supporting the groundwork for the study of basic and applied sciences, initial attempts have been made to explore ways of reforming the scientific research system, thus providing direct experience for initiating a science fund system in China.

Approved by the State Council and established in 1982, the Science Fund of the Chinese Academy of Sciences is a nationwide fund for multidisciplinary natural sciences. Since it was set up 4 years ago, the fund has approved 4,424 subsidized projects with total subsidies of over 172 million yuan. The subsidized projects can be found in some 400 units throughout the country, involving up to 30,000 scientific researchers. According to incomplete statistics for the first half of 1985, 8,228 scientific treatises were completed, 3,097 of which were carried or published in foreign influential academic publications or at scientific conferences. A total of 163 scientific research achievements have passed public appraisal standards or tests by specialists. Some theoretical achievements have reached world advanced levels and are well received by people in the same field at home and abroad, and some achievements of practical use are being tested on a broader scale or popularized.

On 26 December, the Science Fund of the Chinese Academy of Sciences summed up its work over the 4 years since its establishment. Members involved with the fund held that the fund had initially formed a series of management methods which tallied with our national condition in application, examination, approval, and allocation of science funds. The main points of the fund management are macroeconomic guidance, free application, and direct report to a higher body; supporting projects by selecting the most deserving ones in operation through public appraisal by people of the same occupation and examination and approval by a fund group or the Fund; checking and ratifying funds at one go and on an item-by-item basis with funds being allocated by stages and to be used for earmarking funds for specified purposes only; and holding an applicant responsible for the funds he intends to use and expecting the unit where the applicant works to supervise, guarantee, and make regular checks and summaries on how the applicant uses the funds. Of the important points, two should be stressed: One point is to open up a special fund channel, to reform fund allocation methods, and to replace the practice of distributing funds of the basis of the department, the locality, and the unit, and according to the number of people with a method of allocating funds on an item-by-item basis. The other one is to establish a strict and fair assessment and examination system and to replace administrative examination and approval of projects with assessment and examination by specialists.

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CSO: 4008/1035

NATIONAL DEVELOPMENTS

NATIONAL MEETING ON LOCAL SCIENCE WORK

OW121838 Beijing XINHUA in English 1627 GMT 12 Jan 86

[Text] Beijing, 12 Jan (XINHUA)--In the next five years, the State Science and Technology Commission [SSTC] will organize development of 100 items of technology suitable for rural enterprises and manufacture of related equipment.

This was announced by Teng Teng, vice-minister of the commission, at the oepning ceremony of a five-day national meeting on local science work here today, attended by more than 270 people from science and technology commissions and associations in various provinces, municipalities and autonomous regions.

Teng said his commission will also set up 500 demonstration enterprises in the countryside, which will be provided with technological processes, management rules, product designs and quality control methods.

At the same time, he said, the commission will carry out a program to enable one million rural young people with middle school education to learn one or two useful new techniques at short-term courses.

Gao Zhenning, member of the secretariat of the China Association for Science and Technology, told the meeting that scientists and engineers in the association, will make greater efforts to spread technology to rural areas, giving technical training to rural young people and providing technical services to rural enterprises.

Addressing the meeting, State Councillor Fang Yi said the SSTC as a government department and the China Association for Science and Technology as a non-governmental body should cooperate closely at various levels in promoting local economic development by popularizing and applying agricultural technology in line with local conditions.

The on-going economic reform and the expansion of commodity production in rural areas generate a strong need for scientific and technical know-how, he said.

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CSO: 4010/2006

NATIONAL DEVELOPMENTS

CHINA UNIVERSITY OF SCIENCE, TECHNOLOGY THRIVES

HK210855 Beijing ZHONGGUO XINWEN SHE in Chinese 0349 GMT 17 Jan 86

[Article by Zhu Guanghua [2612 0342 5478] selected from the 11 January KEXUE BAO: "The China University of Science and Technology is Brimming With Vigor and Vitality"]

[Text] At the China University of Science and Technology, there is a rich and free academic atmosphere, with various academic schools and talented people giving full play to their abilities. The school is brimming with vigor and vitality.

At a meeting with Hu Yaobang, the celebrated Professor Ting Chao Chung said: "I spent a day at the China University of Science and Technology this time. It was the most pleasant day of my six visits to China. The people I met at the University of Science and Technology are very young and intelligent." He also said to the reception personnel: "Professors Yang Chen Ning and Lee Tsung Dao have been to the China University of Science and Technology. They told me after their return to the United States that the China University of Science and Technology was run very well and that it had the spirit of blazing new trails and was very promising. I spent a day there on this occasion and got the same impressions as theirs. I have decided to take the China University of Science and Technology as my future partner and to go there on my annual return to China."

How is it possible for the China University of Science and Technology to leave an unforgettable impression with others? This is because it is a plot of fertile land for training the pick of scientists. There is an endless array of posters on various academic reports every day. The hosts include academics who enjoy great prestige at home and abroad, as well as undergraduates and postgraduates who have just taken up research work. No attention is paid to either qualifications and record of service or titles and no approval is needed. So long as you have a unique, new, original, and useful idea, you will be able to win over the audience. Different academic schools may also "put on shows on the same stage" so as to make up for each other's deficiencies and to constantly blaze new trails. For example, since its founding in 1973, the astrophysics center of the university has always adhered to the principle of freely proposing research topics, freely forming research groups, and conducting free discussions. They hold a 2-hour academic symposium every Friday, at which one person gives a lecture on a certain topic and joint discussions are held. Although they have different views on the formation of scale pattern [che du jie gou 1439 1653 4814 2845] in the universe, they have always approached the subject together, learned from each other by exchanging views, and thus constantly raised their academic levels. In recent years, the center has contributed more than 200 papers to academic journals at home and abroad and won first and their prizes from the International Gravitational Studies Society in 1985. The center has become an eminent new force in the field of astrophysics.

People say that at the China University of Science and Technology, young people can display their talents and intellectual power to the full. Indeed, the university gives a free hand to young and middle-aged scholars in teaching research, and the administration and allows them to "play a leading role" on the forefront. Its lecturers, the persons responsible for its research projects, the directors of its teaching and research sections and its laboratories, and the responsible persons of its schools, offices, and departments are mostly young or middle-aged persons. The university encourages young people to be pathbreakers on the scientific and technological forefront. Last year, Suzhou hosted an annual symposium on theromophysics. Of the papers read at the symposium, 13 were contributed by this university and, of the 9 persons attending the symposium by invitation, 6 were postgraduate students who either were still studying or had just graduated. This aroused the curiosity of other participants.

In recent years, the university has been pursuing an opening up policy. It has successively sent more than 600 young and middle-aged teachers and students abroad to further their studies. More than 200 of them have returned and they have offered more than 100 new courses at the university. At a recent conferral of academic titles, the university did not take seniority and the number of years of service into consideration. It only took contributions into consideration. Thanks to the decisions made by the university's Academic Titles Committee, the university now has 6 professors and 54 associate professors who are under 45. Some of them are winners of the First Class Major Scientific and Technological Achievements Awards given by the Chinese Academy of Sciences.

Academic freedom necessarily stems from political democracy. Since its founding, the leaders of the university have demonstrated a democratic style. Thanks to the implementation of the principle of making the cadres "more revolutionary, younger in average age, better educated, and more professionally competent," some specialists have assumed leading posts. The university pays close attention to preventing "people in the same fields from intriguing against one another" and encourages its teachers to play their role as masters of the university in running the university. Shortly after the formation of its new leading body, the university organized its Degrees and Academic Titles Committee. A corresponding committee can also be found in each department. Each of these committees has its say on research funding, approving research projects, and the conferment of academic titles and degrees. The university's six leaders are each responsible for specific schools, offices, and departments on a contract basis. They always visit various units in order to find out how things are doing. Saturday afternoons are designated "presidential reception days." The university's president and vice presidents take turn to receive visiting teachers and students. Whoever wants to see the university's leaders on other weekdays can make appointment at their offices. The university has built a teachers' amenity center. The university's leader always participate in their activities on weekends in order to befriend them and to communicate with them. After the central authorities circulated their decision on reforming the education system, the university drafted eight measures for implementing this decision. In addition, it has also solicited opinions at a teachers' congress, where the university's leaders personally listened to queries and faced challenges. At a meeting which lasted less than a half day, President Guan Weiyan ascended the platform seven times to answer questions. The comrades attending the meeting were impressed by the vivid scene.

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NATIONAL DEVELOPMENTS

LIAONING ACHIEVEMENTS DURING SIXTH 5-YEAR PLAN PERIOD NOTED

SK231303 Shenyang Liaoning Provincial Service in Mandarin 1030 GMT 21 Dec 85

[Text] During the Sixth 5-Year Plan period, our province's animal husbandry has vigorously developed. The output of major animal by-products has continuously increased. According to statistics, the province's total meat output this year is estimated at 620,000 tons, thus attaining the target set in the Sixth 5-Year Plan period and showing an increase of 39.6 percent over 1980. The total output of milk products is expected to reach 115,000 tons, exceeding the Sixth 5-Year Plan by 4 percent. The total egg output is expected to reach 311,000 tons, exceeding the Sixth 5-Year Plan by 38 percent. Thanks to the development of animal husbandry, its proportion of output value in the agricultural sector has increased. It is expected that the output value in 1985 will reach 1.97 billion yuan, exceeding the Sixth 5-Year Plan by 4 percent.

During the Sixth 5-Year Plan period, the province has invested 170 million yuan in road construction, has newly built and reconstructed 22 railway overpasses and bridges spanning rivers, and has surfaced highways totaling 210 km. The province has invested 120 million yuan in highway transportation, and has added 1,300 public streetcars and motor vehicles, 400 rental cars, and passenger transport lines totaling 384 km so the situation in which some citizens find it hard to use public bus transportation has been eased slightly.

During this period, we have also witnessed great progress in the development of urban gas supply and the central heating system. The province has increased artificial coal gas and natural gas by 410,000 cubic meters daily and liquified gas by 32,000 tons. The number of gas consumers has increased by more than 200,000. Six cities, including Shenyang, Dalian, and Fushun, have ensured central heating supply to housing areas covering 20 million square meters, accounting for one-third of the province's housing areas.

During the Sixth 5-Year Plan period, Liaoning has scored achievements in preventing and curing endemic diseases which have rarely been seen since the founding of the PRC. The rate of contract various sorts of diseases has dropped by a large margin and diseases have been effectively brought under control. Compared with 1980, the year before the Sixth 5-Year Plan period, the rate of contracting endemic goiter dropped by 35.5 percent and the rate of curing this disease increased by 26.2 percent this year. The incidence of acute and subacute Keshan diseases and the mortality rate of the people suffering from these diseases has been at zero over the past 4 successive years. The number of persons contracting the Kaschin-beck disease dropped by 29 percent.

The number of projects and facilities for preventing fluorine poisoning and improving the water quality and the number of persons who have benefited from this have increased 2.9 times and 4.6 times, respectively. Over the past 5 years, Liaoning's rural areas have carried out six projects for preventing fluorine poisoning and improving the water quality, five of which have been completed. Some 300,000 people have benefited.

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CSO: 4008/1035

NATIONAL DEVELOPMENTS

SHAANXI HOLDS CONFERENCE ON ELECTRONICS INDUSTRY

HK080833 Xian Shaanxi Provincial Service in Mandarin 2300 GMT 6 Jan 86

[Text] The province's electronics industry is discussing the superiority of developing consortium enterprises and the promotion of regional ties. At a recent provincial conference of elections enterprise managers, the managers held that the correct way to invigorate the province's electronics industry is to strengthen extensive economic ties and to give play to local advantages.

During the Sixth 5-Year Plan period, the province's electronics industry developed at an average growth rate of 36 percent in output value. It gradually formed a new base of enterprises focusing on television sets, electronic component parts, electronic calculators, and special electronic devices. The electronics industry has thus become one of the main industries of the province.

The provincial electronics industry department has regarded the development of regional ties and promoting the superiority of consortium enterprises as the key measures for implementing the Seventh 5-Year Plan. In connection with the decision, it has conducted comprehensive investigation and discussion.

The managers participating in the conference held that the decision on promoting ties embodied the spirit of reform. It conformed to reality and was feasible. At present, we should develop ties on two levels. First, we should develop regional ties, which are mainly information exchange, discussion of development strategy, capital raising, and developing markets. Second, we should develop specialized companies, joint companies, and other economic entities so as to improve our production capacity and competitiveness.

The Provincial CPC Committee and government are much concerned about reforms in developing the advantages of electronics industry consortia. Sun Kehua, vice governor, and responsible comrades of the Provincial Planning Committee, the Provincial Economic Committee, and the Provincial Office for Structural Reform also attended the conference. They encouraged the electronics industry to make concerted efforts and advocate reforms, and to make more contributions to invigorating the economy of Shaanxi.

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CSO: 4008/1035

NATIONAL DEVELOPMENTS

BRIEFS

HAN SUYIN'S RESEARCH FUND--Beijing, 12 Jan (XINHUA)--British writer Dr. Han Suyin announced the establishment of the Han Suyin trust fund for scientific exchanges between China and Europe at a press conference here today. The first nongovernmental organization of its kind, it will help train Chinese scientific decision makers and promote exchanges of researchers between China and other countries. Chinese women scientists will benefit from 50 percent of the fund's money, Dr. Han said. Dr. Han, 68, president of the fund, told reporters that she expects to increase the fund gradually through the money she earns from her books. All seven members of the board of directors will give their services voluntarily, she stressed. Han arrived here 9 January as a guest of the Chinese People's Association for Friendship with Foreign Countries. [Text] [Beijing XINHUA in English 1030 GMT 16 Jan 86 OW] /12712

CAS FUND AIDS YOUNG SCIENTISTS--Beijing, 15 Jan (XINHUA)--The Chinese Academy of Sciences [CAS], for the first time, has provided a total of 2.51 million yuan to aid 140 young scientists in their research. Earlier last year, the academy set up a science fund to foster young scientists under the age of 35. The youngest to receive a grant is 22 years old, and 13 have studied abroad. Zhang Yingzhi of the Shanghai Institute of Organic Chemistry, who received a PhD at London University, was granted a sum of 40,000 yuan for her research on the application of palladium complex compound in organic synthesis. Qian Min, 22, of the Purple Mountain Observatory in Nanjing, received a fund of 15,000 yuan for research on satellite measurement and control data processing. A CAS official said the academy would continue to allocate a certain sum every year for scientific research undertaken by promising young scientists. [Text] [Beijing XINHUA in English 1235 GMT 15 Jan 86 OW] /12712

CAS EXPANDS DOMESTIC, FOREIGN TIES--Beijing, 27 Jan (XINHUA)--China's open policy has enabled its Academy of Sciences to expand its ties with institutions both inside and outside of the country. By the end of 1985, the Chinese Academy of Sciences [CAS] had signed long-term scientific and technical cooperation agreements with 12 provinces, municipalities, ministries and a number of open coastal cities. The branch institutes offer technical services, including sharing scientific results and offering technical consulting. More than 100 cooperatives have been set up between the branch institutes and production units, and thousands of scientists and technicians have been invited to be technical advisors and directors. Last year, the CAS opened two Beijing institutes--the Institute of Theoretical Physics and the Institute of

Mathematics--and 17 laboratories to scientists and researchers. More than 700 scientists from the fields of education, scientific research and industrial businesses and 32 foreign experts have been approved to work in these institutes and laboratories. CAS has contacts with 50 countries and regions and has concluded 43 agreements and memoranda on science and technology. While setting up cooperative agreements with foreign partners, the academy has attracted a number of international academic conferences and foreign scholars to China. [Text] [Beijing XINHUA in English 1030 GMT 27 Jan 86 OW] /12712

GRADUATE STUDENT ENROLLMENT--Beijing, 30 Aug (XINHUA)--Registration started today for the 43,416 master's degree students enrolled this year, according to the State Education Commission. This figure almost doubled last year's figure of 22,920. Classes will begin next week. In Beijing, where schools of higher learning and research institutes are more concentrated, the enrollment reached over 10,600, surpassing the annual figure of the previous years and making up for one-third of the nation's total. Among the new recruits in Beijing, 34 percent are on-the-post university graduates. In addition, as a trial practice in reforming the enrollment system, Beijing has also included in its total, over 800 outstanding college graduates who were enrolled at the recommendation of their colleges without taking an entrance examination. [Text] [Beijing XINHUA in English 0758 GMT 30 Aug 85 OW] /12712

GUANGDONG'S SCIENTIFIC RESEARCH UNITS--In the wake of reforms, some 90 percent of Guangdong's scientific and technological research units have established comprehensive links with production ones. Over the past four years, the research units developed one new achievement per day on average. In addition, about 30 percent of the achievements made were popularized and totally brought about more than 500 million yuan of economic results. [Summary] [Guangzhou Guangdong Provincial Service in Mandarin 1000 GMT 20 Jan 86 HK] /12712

MANAGEMENT REGULATIONS ADOPTED--Beijing, 16 Dec (XINHUA)--China's first state standards for managing radio science--"requirements in Electromagnetic Environment for Aeronautical Navigation Stations"--were approved today after examination. The examination was jointly sponsored by the relevant departments of the State Council and the Central Military Commission. Representatives, experts, and professors from 49 units all over the nation held that the "Requirements in Electromagnetic Environment for Aeronautical Navigation Stations," which scientifically solves the growing problem of mutual interference between aeronautical and non-aeronautical navigation stations, marks a shift from management of radio science based on experience to scientific management. [By reporter Sun Maoging] [Text] [Beijing XINHUA Domestic Service in Chinese 0837 GMT 16 Dec 85 OW] /12712

CSO: 4008/1035

PHYSICAL SCIENCES

ON COMPUTER-AIDED PROGRAMMING OF PAL DEVICES

Hangzhou ZHEJIANG DAXUE XUEBAO (ZENGKAN) [JOURNAL OF ZHEJIANG UNIVERSITY (SUPPLEMENT)] in Chinese "Special Issue on Computers" 25 Jul 85 pp 124-132

[Article by Tao Xin [7118 2946] and Pu Shuliang [3184 2885 5328]]

[Text] Abstract: Programmable Array Logic (PAL) is a new semi-conductor device with powerful functions and broad applications. On the basis of an in-depth analysis of the PAL-20 series products produced by the U.S. MMI [Monolithic Memories, Inc.] company, this paper designed a PAL device programmer which can be connected to any computer as long as it has a parallel interface. This paper provides the hardware logic diagram and the software programming flowcharts. It will be an effective tool for computer hardware developers.

I. Overview

1. Characteristics of PAL Devices

The PAL device is a new fusable programmable integrated circuit which appeared on the heels of other programmable ROM. With the constant development of large scale integrated circuits, the functions of single chip integrated circuits became more and more powerful, and the appearance of CPU and various programmable interface chips provided the material foundation for developing computer systems which were small in size and powerful in functions. However, in addition to requiring a small number of LSI (large scale integrated circuits), a computer hardware system also must have a fairly large number of SSR (small scale integrated circuits) and MSI (medium scale intergrated circuits) to coordinate between the LSI devices, and frequently in the physical space of a complete hardware system, this part takes up a very large proportion which is an important factor influencing the reliability of the system's operation because the large use of SSI and MSI devices increases the complexity of the wiring and thus the assembly precision of printed circuit boards could not be improved. This is a problem which frequently troubles computer logic designers now.

To be sure, if it was only to reduce mass, these SSI and MSI devices could be integrated into one chip using LSI technology, but it must be understood that these SSI and MSI devices in a system are very irregular and it is difficult to increase the degree of integration; furthermore, designing and developing a special use integrated circuit for one special system not only lengthens the development time and increases costs, but it also loses the advantage of MSI-SSI flexibility. Therefore, this method is not adoptable.

The bipolar PAL device provided by the U.S. MMI company and others satisfactorily resolves the above contradiction. It has both the high speed of the TTL and the flexibility of programmability and is now a widely used device in the design of computer hardware systems and other digital systems.

In addition to high speed and flexibility, PAL has an even more valuable characteristic of a high degree of privacy of its internal information, thus it is very difficult for competitors to dissect and reproduce it. Of course, this characteristic is a great difficulty for China which has adopted a policy of analyzing imported technology and then developing our own products. Thus, promoting the use of PAL devices first of all requires solving the two problems of how to analyze wired PAL devices in programmed systems and how to program PAL devices on the basis of our own design demands. The degree of emphasis of these two tasks is different and relatively independent. This paper discusses primarily the latter. The author plans another paper discussing the problem of analyzing wired PAL devices.

2. Method of Representing PAL

As discussed above, devices developed on the basis of fusible PROM, and is a special form of PROM. The two are made up of an array of AND-OR gates. For ease of discussion, the following symbols will be used to represent the AND-OR array. Figure 1 is an AND-OR array which has two input terminals and one output terminal. Its ordinary logic form can be described as

$$\text{OUTPUT} = (L_1 + \bar{f}_1)\ (L_1 + \bar{f}_2)\ (L_2 + \bar{f}_3)\ (\bar{L}_2 + \bar{f}_4)$$

$$+ (L_1 + \bar{f}_5)\ (\bar{L}_1 + \bar{f}_6)\ (L_2 + \bar{f}_7)\ (\bar{L}_2 + \bar{f}_8)$$

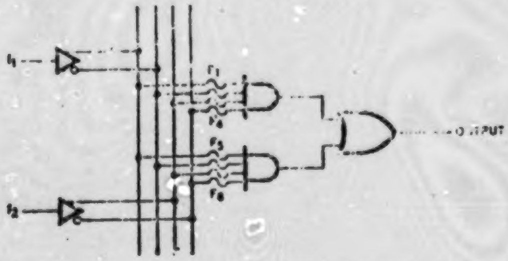


Figure 1

in which L_1 and L_2 are input signals and f_1 is the fuse state in the array: f=0 means the fuse is blown; f=1 means the fuse is retained.

In an unprogrammed PAL device, all the fusable links still exist, thus its initial OUTPUT = 0.

For convenience, the logic diagram such as the one illustrated in Figure 1 is simplified to the form given in Figure 2. This is different from the method of representing ordinary logic circuits.

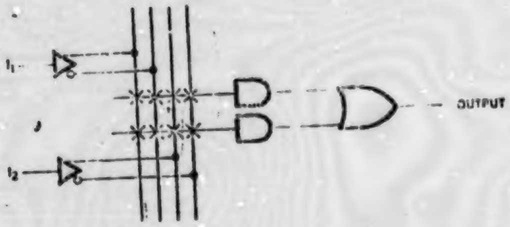


Figure 2

If we wish to establish the following logical equation:

$$OUTPUT = L_2 \cdot L_2 + L_1 \cdot L_2$$

we can represent it with Figure 3.

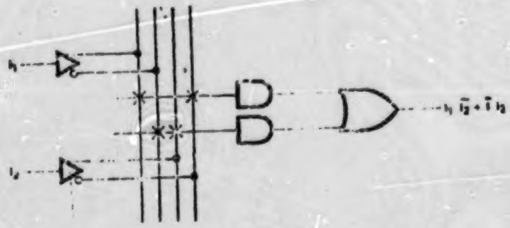


Figure 3

The points of intersection marked X mean the fuses still exist, and those without Xes are points where fuses have been blown.

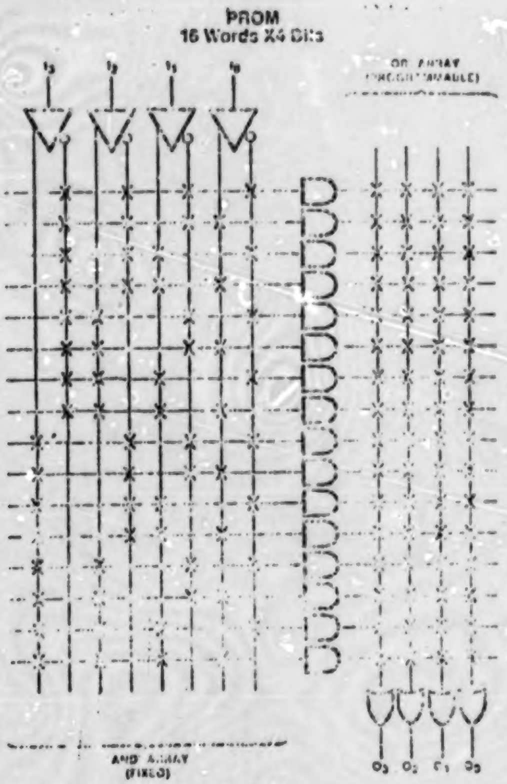

PROM
16 Words X4 Bits
I_3
I_2
I_1
I_0
OR ARRAY
(PROGRAMMABLE)
AND ARRAY
(FIXED)
O_3
O_2
O_1
O_0

Figure 4

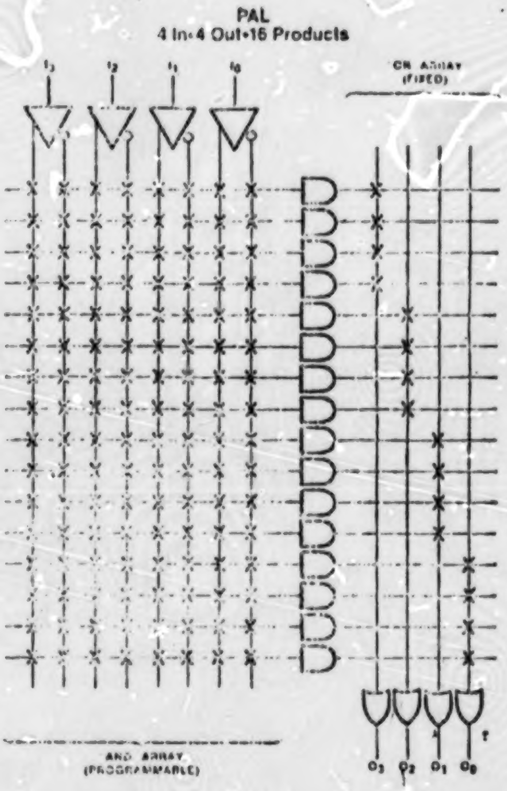

PAL
4 In•4 Out•16 Products
I_3
I_2
I_1
I_0
OR ARRAY
(FIXED)
AND ARRAY
(PROGRAMMABLE)
O_3
O_2
O_1
O_0

Figure 5

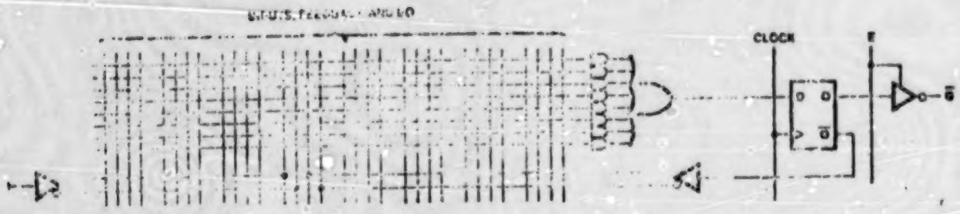

CLOCK
E
D
Q
$\overline{Q}$
$\overline{Q}$

Figure 6

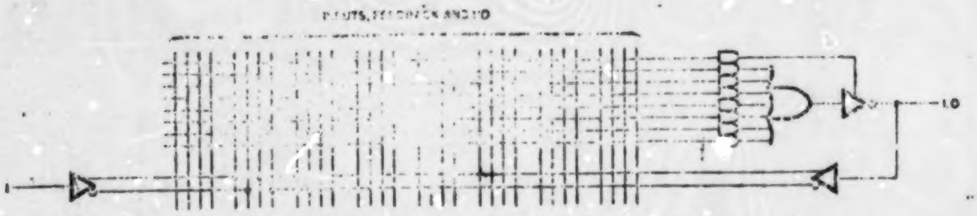


Figure 7

3. Comparison of PAL and PROM

The primary differences between PAL and PROM are: the AND gate arrays in PROM devices are burned in, and the OR gate arrays are programmable; it is the opposite with a PAL device, its AND gate is programmable and the OR gates are burned in, as illustrated in Figures 4 and 5 respectively. In addition, some types of PAL devices use register output and their output also feeds back as part of input, as illustrated in Figure 6, some pins of PAL devices can be input and can also be output, programmable by the user, as illustrated in Figure 7. For this reason, the PAL devices are more flexible than PROM in constructing logic circuits.

II. Programming Principles of PAL Devices

This paper discusses mainly the PAL-20 series products produced by the U.S. MMI company.

The PAL device is programmed by blowing some fuses in the device and leaving some fused, depending on the logic functions which the user wishes to implement. As mentioned above, the PAL device is different from the PROM: when programming a PROM, fuse selection is sequentially selecting the fuse node conveniently through continuous changes in the address wires, but programming the PAL device requires only the AND gate array fuses, its internal design is made up of 32 input lines and 64 product lines forming a 32 x 64 fuse node matrix. The number of fuses and their distributional position included in different model devices are different, as explained by the factory's product manual. These 32 input lines and 64 product lines are clear to the user. When the user is programming, he needs only to apply different levels to external pins (this array has 20 pins) to make the selection of input lines and product lines and thus at once determine a fuse which must be programmed.

As an example, we will explain the programming principles by the method of using a PAL device to make up a six gate circuit.

Supposing the logic equation of a six-gate circuit was respectively,

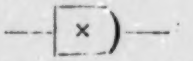
$$B = \bar{A};\ E = C*D;\ H = F+G;$$

$$O = \bar{M}*\bar{N};\ R = P*\bar{Q}+\bar{P}*Q;\ L = \bar{I}+\bar{J}+\bar{K}$$

The steps are roughly as follows:

1) Select the suitable model on the basis of design demands. In this example, six output terminals and 12 input terminals are required, and high level output is effective. On this basis, selecting PAL12H6 will satisfy the demand.

2) Each pin on the device is named corresponding to the demands, such as 1-C; 2-D....18-B, 19-A, as illustrated in Figure 8.

3) Select the fuse state, i.e., on the basis of the logic equation determine which fuses should be blown and which should be retained. For example, to obtain $B = \bar{A}$, find in the diagram the output terminal defined as B. It corresponds to four product lines, labeled respectively 8, 9, 10, and 11. Each of the product lines is related to the positive/negative variable of 12 input terminals, finding the input line corresponding to $\bar{A}$ is 7, an x is placed at the intersection of product line 8 and input line 7 to indicate that this fuse should be retained, and the other fuses on product line 8 are all blown, thus the AND gate output corresponding to product line 8 is A and all the fuses on product lines 9, 10, and 11 are all retained, represented in the figure by  , the output of these three AND gates is 0, therefore, the output of the AND-OR gate is $\bar{A}$. By the same token, to get E = C*D, on the 16th product line corresponding to E output the intersecting fuses of input lines 0 and 1 related to C and D are retained and the others are all blown and the fuses on the other product line corresponding to E are all retained. Proceeding in this fashion one can obtain the fuse state diagram illustrated in Figure 8.

4) On the basis of the fuse state information obtained above, a programmed pulse applied to the fuse nodes which must be blown, blows the fuses.

The first two steps in the process described above are easily determined by the user on the basis of design demands and with reference to the appropriate reference manuals. If the third step is carried out manually, it will be a very tedious job and not only will it take a great deal of time but it is also easy to make a mistake and since the programming of a PAL device is a one-time thing, once there is a failure, the device must be scrapped. For this reason, a special procedure--a "logic converter" program--provided by the programmer carries it out. The fourth step cannot be undertaken manually, either. It is carried out by the programmer's special hardware module--the

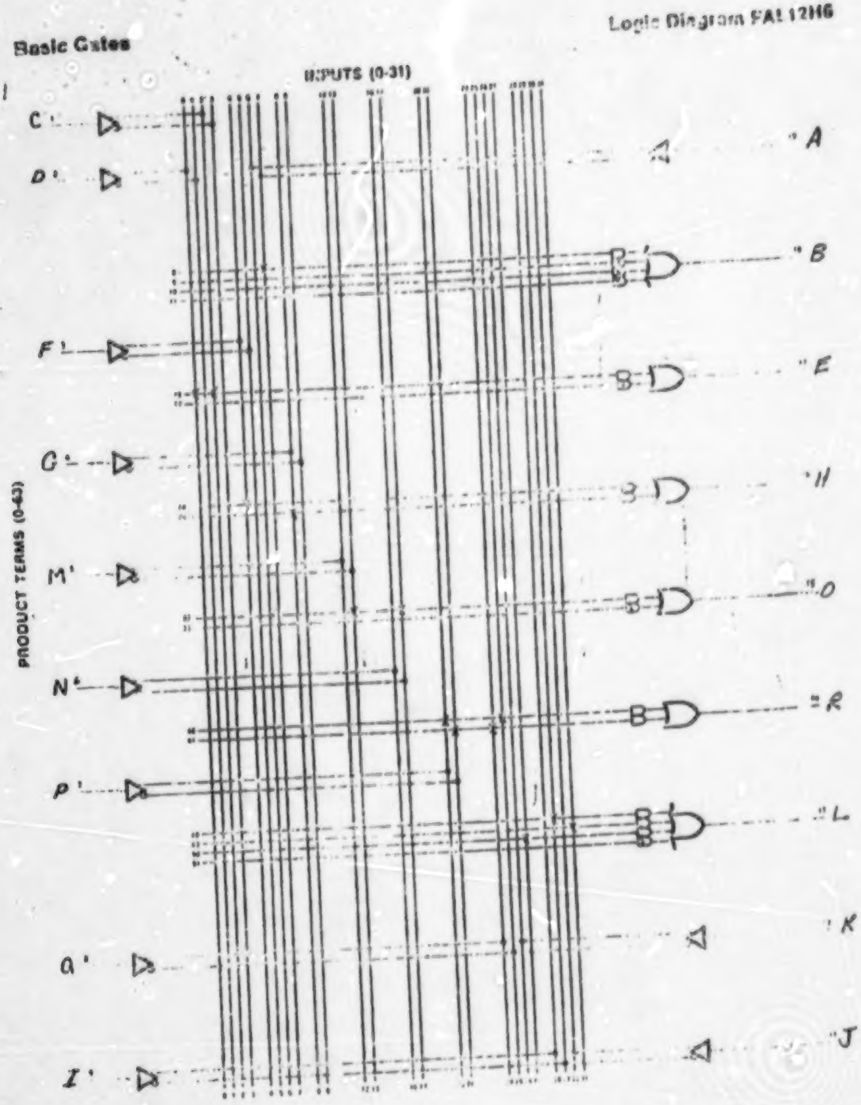

Basic Gates
Logic Diagram PAL12H6
INPUTS (0-31)
PRODUCT TERMS (0-63)
C'
D'
F'
G'
M'
N'
P'
Q'
I'
A
B
E
H
O
R
L
K
J

Figure 8

programming circuit--with the help of a suitable control program. The logic converter program and the programming circuit are the two central modules of the entire programmer and below we will stress the design thinking of these two modules in a brief discussion.

III. Hardware and Software Design of the PAL Programmer

1) PAL Programming Circuit

The main function of the programming circuit is to provide, on the basis of the PAL device's internal decoding mechanism, the combined signal of a specially designated level for the device's pins in order to select the internal input lines and product lines and produce a programming pulse.

Determination of the level signal group method is derived from the input line select and product line select truth table provided in the factory's product guide. It is as illustrated in the tables below.

INPUT LINE NUMBER	PIN IDENTIFICATION								
	I_7	I_6	I_5	I_4	I_3	I_2	I_1	I_0	LIR
0	HH	HH	HH	HH	HH	HH	HH	L	Z
1	HH	HH	HH	HH	HH	HH	HH	H	Z
2	HH	HH	HH	HH	HH	HH	HH	L	HH
3	HH	HH	HH	HH	HH	HH	HH	H	HH
4	HH	HH	HH	HH	HH	HH	L	HH	Z
5	HH	HH	HH	HH	HH	HH	H	HH	Z
6	HH	HH	HH	HH	HH	HH	L	HH	HH
7	HH	HH	HH	HH	HH	HH	H	HH	HH
8	HH	HH	HH	HH	HH	L	HH	HH	Z
9	HH	HH	HH	HH	HH	H	HH	HH	Z
10	HH	HH	HH	HH	HH	L	HH	HH	HH
11	HH	HH	HH	HH	HH	H	HH	HH	HH
12	HH	HH	HH	HH	L	HH	HH	HH	Z
13	HH	HH	HH	HH	H	HH	HH	HH	Z
14	HH	HH	HH	HH	L	HH	HH	HH	HH
15	HH	HH	HH	HH	H	HH	HH	HH	HH
16	HH	HH	HH	L	HH	HH	HH	HH	Z
17	HH	HH	HH	H	HH	HH	HH	HH	Z
18	HH	HH	HH	L	HH	HH	HH	HH	HH
19	HH	HH	HH	H	HH	HH	HH	HH	HH
20	HH	HH	L	HH	HH	HH	HH	HH	Z
21	HH	HH	H	HH	HH	HH	HH	HH	Z
22	HH	HH	L	HH	HH	HH	HH	HH	HH
23	HH	HH	H	HH	HH	HH	HH	HH	HH
24	HH	L	HH	HH	HH	HH	HH	HH	Z
25	HH	H	HH	HH	HH	HH	HH	HH	Z
26	HH	L	HH	HH	HH	HH	HH	HH	HH
27	HH	H	HH	HH	HH	HH	HH	HH	HH
28	L	HH	HH	HH	HH	HH	HH	HH	Z
29	H	HH	HH	HH	HH	HH	HH	HH	Z
30	L	HH	HH	HH	HH	HH	HH	HH	HH
31	H	HH	HH	HH	HH	HH	HH	HH	HH

Table 1 Input Line Select

PRODUCT LINE NUMBER	PIN IDENTIFICATION						
	O_3	O_2	O_1	O_0	A_2	A_1	A_0
0, 32	Z	Z	Z	HH	Z	Z	Z
1, 33	Z	Z	Z	HH	Z	Z	HH
2, 34	Z	Z	Z	HH	Z	HH	Z
3, 35	Z	Z	Z	HH	Z	HH	HH
4, 36	Z	Z	Z	HH	HH	Z	Z
5, 37	Z	Z	Z	HH	HH	Z	HH
6, 38	Z	Z	Z	HH	HH	HH	Z
7, 39	Z	Z	Z	HH	HH	HH	HH
8, 40	Z	Z	HH	Z	Z	Z	Z
9, 41	Z	Z	HH	Z	Z	Z	HH
10, 42	Z	Z	HH	Z	Z	HH	Z
11, 43	Z	Z	HH	Z	Z	HH	HH
12, 44	Z	Z	HH	Z	HH	Z	Z
13, 45	Z	Z	HH	Z	HH	Z	HH
14, 46	Z	Z	HH	Z	HH	HH	Z
15, 47	Z	Z	HH	Z	HH	HH	HH
16, 48	Z	HH	Z	Z	Z	Z	Z
17, 49	Z	HH	Z	Z	Z	Z	HH
18, 50	Z	HH	Z	Z	Z	HH	Z
19, 51	Z	HH	Z	Z	Z	HH	HH
20, 52	Z	HH	Z	Z	HH	Z	Z
21, 53	Z	HH	Z	Z	HH	Z	HH
22, 54	Z	HH	Z	Z	HH	HH	Z
23, 55	Z	HH	Z	Z	HH	HH	HH
24, 56	HH	Z	Z	Z	Z	Z	Z
25, 57	HH	Z	Z	Z	Z	Z	HH
26, 58	HH	Z	Z	Z	Z	HH	Z
27, 59	HH	Z	Z	Z	Z	HH	HH
28, 60	HH	Z	Z	Z	HH	Z	Z
29, 61	HH	Z	Z	Z	HH	Z	HH
30, 62	HH	Z	Z	Z	HH	HH	Z
31, 63	HH	Z	Z	Z	HH	HH	HH

Table 2 Product Line Select

In the table, L = low level input voltage

H = high level input voltage

HH = high level programming volcage

Z = high impedance

It is not hard for us to find the selection rules in the truth tables. From the product line select table we can tell that the conversion rules of pins $A_0A_1A_2$ can actually be described as a binary counter and the conversion rules of O_0-O_4 can be described as a shift register. The counter and register output drive a special driver circuit which has two states Z and HH, and from the input line select table we can tell that the L/R signal can be described as a flip-flop that operates in counting mode, so that each time the product line changes twice, L/R changes once. The conversion rules of signals A_0-A_7 also can be described as a shift register of successive shifts. The difference from the above is that the A_0-A_7 signals are driven by a special driver circuit which has the three states H, L, and HH.

In addition, the PAL device designers cleverly designed a completely symmetrical internal array, and thus the 2048 fuse nodes can be programmed twice, programming the former 1024 and the latter 1024 separately, requiring only that the pins be given different definitions but not requiring that the connections be changed. This is as illustrated in Figure 9.

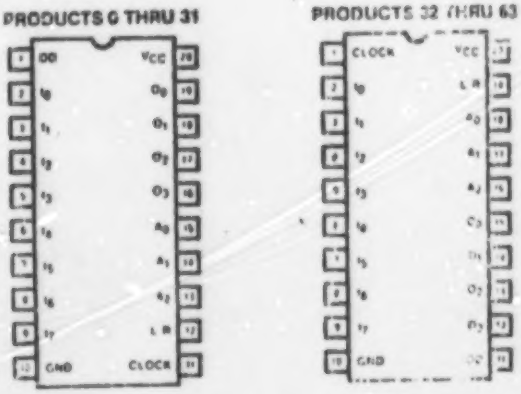


Figure 9

I_0-I_7 and L/R are used for selecting the input line

O_0-O_3 and A_0-A_2 are used for selecting the product line

OD - output prohibited

The arrangement in the left hand figure is for programming product lines 0-31 (the former 1024 fuses) and the arrangement on the right is for programming product lines 32-63 (the latter 1024 fuses).

The handbook provided by the PAL device manufacturer provides the rules which must be obeyed by the programming signals, as illustrated in Figure 10, and on the basis of these rules it is very easy to use a multilevel delay circuit.

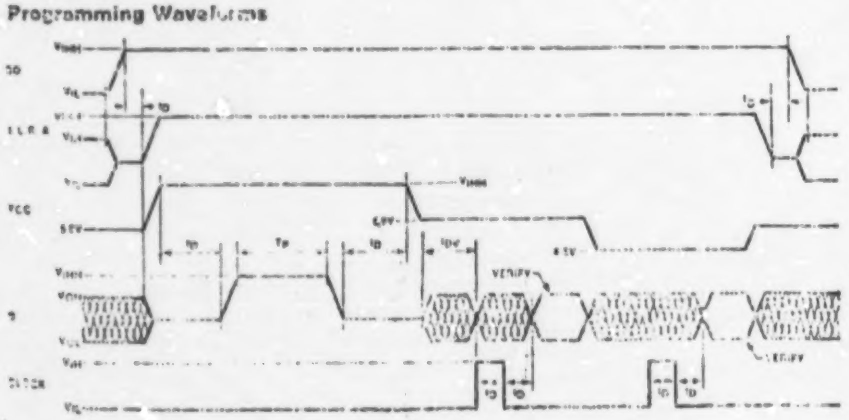


Figure 10

Summarizing the above, we can draw the logic diagram illustrated in Figure 11.

In the figure, AOH is a special two-state driver circuit, having two output states Z and HH; OCIH is a special three-state driver circuit, having three output states H, L, and HH. There are no readymade products for these special driver circuits, and our own design has demonstrated through simulation testing that it conforms completely to demands.

The entire logic system has only four signals to the outside, i.e., pure "0" sets fuses to initial state once, starts programs address conversion--prepares for programming once, pin redefinition--after 1024 fuses have been programmed, the pins are redefined for programming the other half of the fuses. This system can be linked by parallel interface to any computer to form a general purpose PAL programmer.

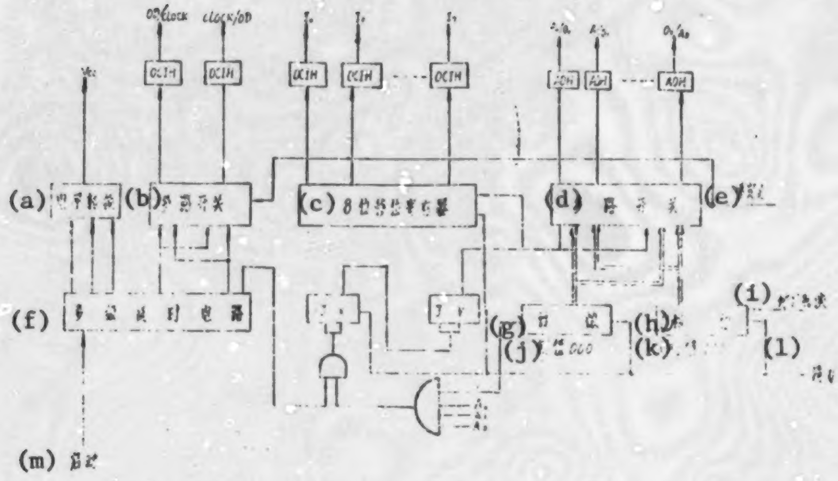


Figure 11

Key:

a. Level conversion
b. Multiplex switch
c. 8-place shift register
d. multiplex switch
e. Redefinition
f. Multilevel delay circuit
g. Counter [?]
h. Shift
i. Address conversion
j. Initial value 000
k. Initial value 000
l. Clear 0
m. Start

2) Logic Conversion Program

*Main function: Depending on the user's design demands, a model is selected. The model along with logical expression form is input to the computer in character string form through an interactive terminal, then a fuse state information table or diagram which as programming control basis is produced.

*Main algorithm: Since the distribution of the PAL device's internal fuses is unified in a 32x64 matrix form, one naturally thinks of mapping the 32x64 fuse matrix as a logical two dimensional mathematical array LFUSES (32x64) with each element in the logic array corresponding one to one with the corresponding fuse position. If an element is "true" it means the fuse is blown, if it is "false," it means that the fuse is preserved. The reverse is also possible.

Thus, the problem can be resolved into how to obtain this logical mathematical array. For this, the following factors must be considered:

(A) The device type: As we said above, the number and distribution of fuses in different models is different. For example, the numbering and quantity of product lines corresponding th output of one and the same pin in different types of devices is not always identical. Thus it is necessary to find the coefficient relationship for each type to be able to determine the product line pointer conveniently, depending on the type.

(B) Pin definition: To use the flexibility of PAL design fully, the name of each pin is defined entirely by the user. One can both define the original variable as well as define the contravariable, for example, pin 1 can be defined as LGP as well as LGP [sic]. Thus, when the variable names in an input logical expression are compared with the pin definition, the two are the same (match) indicating that they are positive or negative in common. The reason why this factor should be considered is that from the PAL logic diagram we know that the junctions of each input pin on the input line are neighboring, i.e., the primary signal is an even number and the contrasignal is an odd number. When the symbols in a logical expression are identical to the pin definition symbols, selecting an even numbered input line, or conversely, selecting an odd numbered one.

(C) From the PAL logic diagram we know that the corresponding relationship of pins of different type devices and input lines is relatively fixed. For example, the first pin corresponds to the second and third input line, the second pin corresponds to the zero and first input line. Thus, when defining pin names, as long as one goes strictly by the sequential order, once the names in the logical expression match the defined names, the pins will be determined correspondingly and the input lines will be determined correspondingly, and considered again in connection with the factor (B), one will at once be able to find the input line number, find the product line number and select the fuse position at once, and thus correspondingly determine the element position in the mathematical array.

Therefore the logic conversion program compares the symbols in the logical expression with the predefined pins and once there is a match, the corresponding fuse position is mapped to a corresponding element of a two-dimensional mathematical array. The flow chart is illustrated in Figure 12.

In the flowchart, the entire mathematical array ISYM (8,20) corresponds to 20 pin names and the logical mathematical array LFUSES (32,64) corresponds to the fuse matrix. The variable IBUF marks the positive and negative of the input variables.

When the logic conversion program has been completed, we finally obtain a two-dimensional mathematical array in logical form to make it easy for the user to search and print out the two-dimensional array information as 0/1 or H/L symbols in a 32x64 matrix form. This is the fuse state information table or information map required.

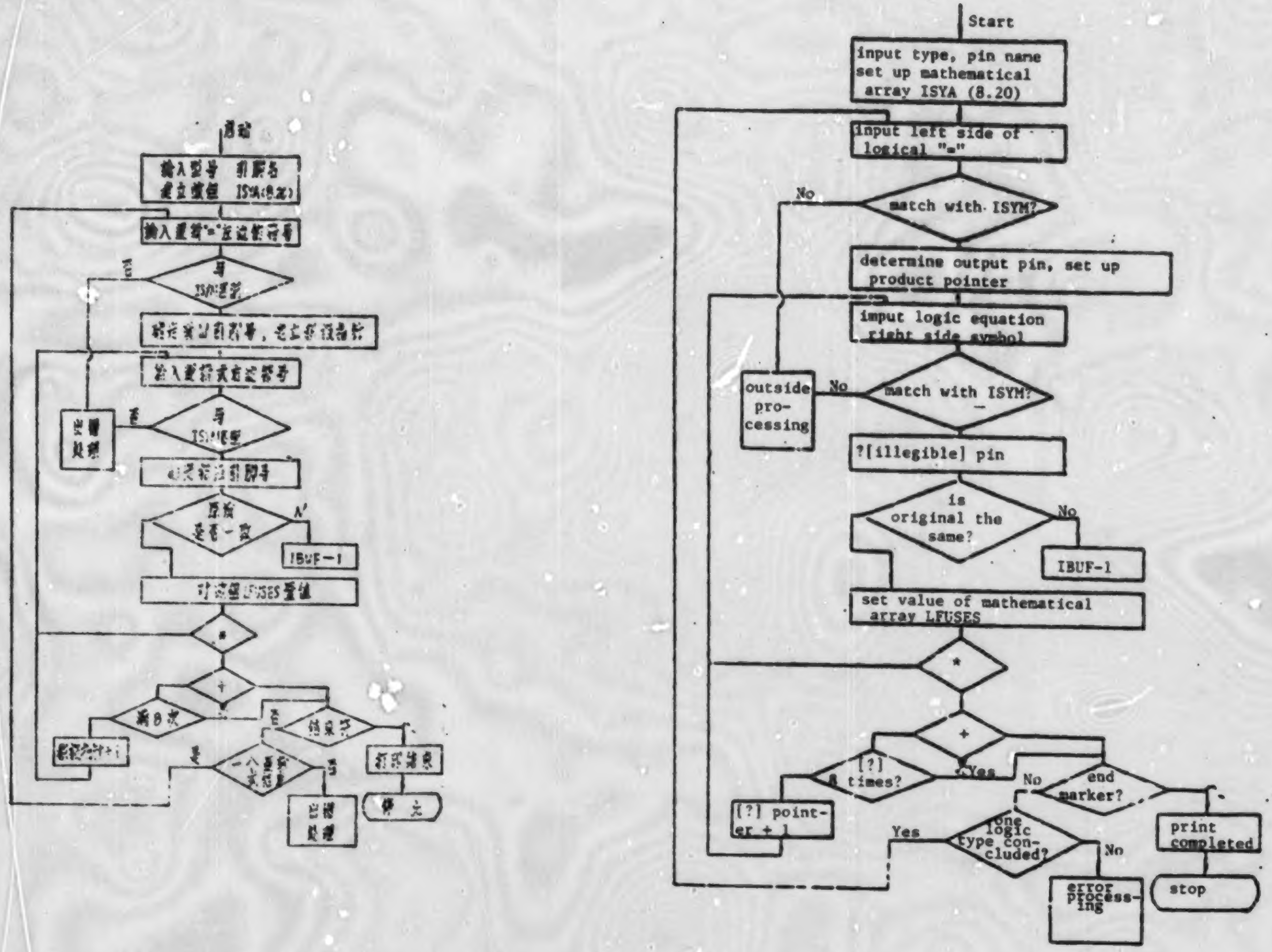

Start
input type, pin name set up mathematical array ISYA (8.20)
input left side of logical "="
match with ISYM?
No
determine output pin, set up product pointer
imput logic equation right side symbol
match with ISYM?
No
outside processing
?[illegible] pin
is original the same?
No
IBUF-1
set value of mathematical array LFUSES
*
+
[?] 8 times?
Yes
[?] pointer + 1
No
end marker?
print completed
stop
Yes
one logic type concluded?
No
error processing
IBUF-1

Figure 12

We can use this fuse state information to control the program which is fairly simple and we will not discuss it here.

IV. Conclusion

Above we have described computer-aided programming method for PAL devices and we have designed the related hardware and software. In view of the fact that China now uses imported foreign advanced systems as references and after analyzing them transplants them or develops her own products, if we use devices in existing systems to copy the devices we ourselves need, this is also a significant task, and as was pointed out earlier, because of the special PAL privacy, such copies are very difficult. The authors have carried out some explorations in this area and designed the relevant hardware and software and analyzed programmed PAL devices and obtained their logical expressions and using this logical expression to input the programmer described in this article indirectly obtained a copy. However, this task is now still limited to some types of devices and we are still searching for devices which certain powerful functions. Combining the analysis and programming systems will create a powerful hardware development system.

References

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[3] BIPOLAR LSI DATA BOOK MMI.

8226/8309
CSO: 4008/1016

APPLIED SCIENCES

IMPROVED Y-7, Y-12 AIRCRAFT DESCRIBED

Beijing HANGKONG ZHISHI [AEROSPACE KNOWLEDGE MAGAZINE] in Chinese No 12, Dec 85 p 3

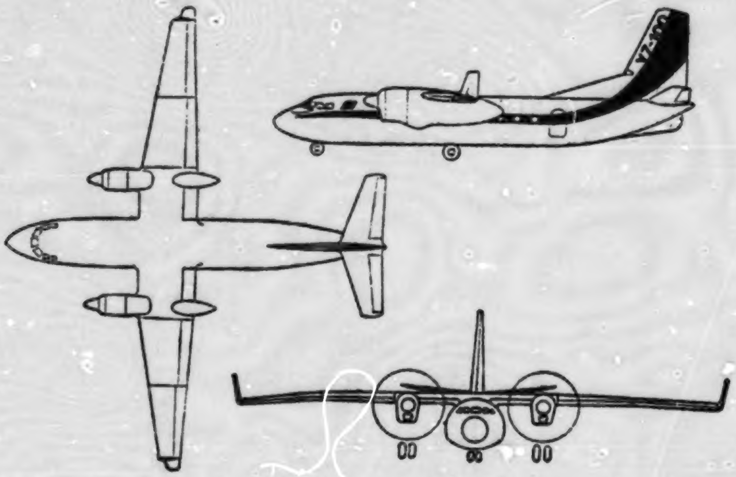
[Article by Bu Shilin [0592 4258 2651]]

[Text] In late September, the climate in Beijing was delightful, and the city was getting ready for the 36th anniversary of the People's Republic; at the same time, it was celebrating the successful adjournment of the National Party Congress. On the parking area of the Nanwan Airport stood two Chinese-made civilian airplanes painted bright white with red and blue stripes.

One was the Chinese-made Y-7 aircraft. After the first successful test flight in 1982, significant improvements have been made over the past 3 years to enhance its performance. During the period from January to August of this year, a joint effort was initiated between the Chinese Technology Import/Export Co. and the Hong Kong Aircraft Engineering Co. (MAECD) to convert the more than 30 electronic and other airborne equipment on the Y-7 aircraft. This equipment includes: the environment control system, the atmospheric data system, the ultra-shortwave radio station, the magnetic navigation reference system, the attitude reference system, the Omega navigation system, the weather radar, the guidance system, the ranging device, and the bearing receiver. In addition, improvements were made in the passenger cabin: fireproof sealing materials were used, light-weight, comfortable seats were installed, and sound-proofing measures were taken to reduce the noise level by 8 dB. New air-conditioning units, reading lights, and oxygen supply equipment were also installed. As a result of using advanced electronic equipment, the number of flight crew was reduced from 5 to 3, thus making room for two more passengers. The total number of passengers is 52. The Y-7 aircraft is equipped with two W15A-1 turboprop engines, each with a maximum rated take-off shaft power of 2,650 hp and a design life of 9,000 hours. The converted Y-7 is called the Y-7-100. In terms of electronic equipment, the aircraft has comparable technology as the Boeing 737; in terms of cabin facilities, it is more advanced than the Soviet An-24 aircraft.

The other aircraft was the Y-12, which is an improved version of the Y-11, a multi-function light aircraft. It has two engines, a high wing design, a single vertical tail assembly, and fixed tricycle landing gear. The engine is a Pratt and Whitney PT6A turboprop imported from Canada; its usable power is 620 shaft hp. The Y-12 can carry 17 passengers, has a maximum cruising speed of 328 km/hr, and can take off and land on unimproved runways. Agreement was made with MAECD to convert its interior by installing comfortable chairs, air-conditioning system, lighting and call systems, and reducing the noise and vibration levels; its exterior was coated with high-quality paint.

During the 2-day exhibit on 26 and 27 September, the aircraft were visited by delegates at the Party Congress, and representatives of the China Aviation Establishment, Air Force and Naval units of the People's Liberation Army, the Commission of Science, Technology and Industry for National Defense, and the Ministries of Geology, Agriculture and Forestry, Posts and Telecommunications, and Finance. Everyone was pleased with the improvements made to the airplanes and hoped that they would soon be available for service.



Technical Data of the Y-7

Exterior dimensions:	
Wing span	29.639 m
Length	23.700 m
Height	8.553 m
Wing area	74.98 m^2
Interior dimensions:	
Length of cabin	10.50 m
Width of cabin	2.80 m
Height of cabin	1.90 m
Cabin volume	56.0 m^3
Forward luggage compartment	4.5 m^3
Rear luggage compartment	6.7 m^3
Weight and payload:	
Maximum take-off weight	21,800 kg
Maximum landing weight	21,800 kg

Empty weight	14,900 kg
Maximum fuel capacity	4,790 kg
Maximum effective payload	5,500 kg
Maximum commercial payload	4,700 kg

Performance data:	
Maximum level flight speed	518 km/hr
Maximum cruising speed	484 km/hr
Efficient cruising speed	423 km/hr
Sea-level climb rate	7.64 m/sec
Operating ceiling (dual engine)	8,750 m
Operating ceiling (single engine)	3,900 m
Take-off distance	
(sea-level, international standard atmosphere)	1,248 m
(sea-level, international standard atmosphere ±20°C)	1,398 m
Landing distance	620 m
Range (carrying 52 passengers)	910 km
Range (full fuel capacity)	
(without auxiliary tank)	1,900 km
(with auxiliary tank)	2,420 km

3012/6091
CSO: 4008/33

APPLIED SCIENCES

DETAILS OF Y-12I STOL AIRCRAFT PRESENTED

Beijing HANGKONG ZHISHI [AEROSPACE KNOWLEDGE MAGAZINE] in Chinese No 12, Dec 85 pp 4-5

[Article by Song Zhaolin [1345 2600 2651]]

[Text] On 29 February 1984, a big crowd gathered at the Hebei Chengde Airport to witness a demonstration flight test of the Y-12I aircraft.

The Y-12I is a newly developed, twin-engine turboprop, short take-off and landing multi-function airplane. It can be used for transportation, parachuting as well as for various applications in geology, agriculture and forestry; it can also be converted into a special-purpose airplane for precision search operation. Development of the airplane began in 1980 based on design guidelines specified in section 23 of the U.S. Federal Aviation Regulations. After the completion of feasibility studies, design, manufacturing, and flight tests, the Y-12I successfully passed the technical certification on 17 December 1983 by a certification committee organized jointly by the Ministry of Aviation Industry and the Ministry of Geology and Mineral Resources, and was officially approved for service.

Design Features

The fuselage of the Y-12I has a semi-rigid metallic structure, and is divided into three sections: the forward cabin, the passenger/cargo cabin, and the forward and rear luggage compartments. Below the passenger/cargo cabin are two subwings which are used as anchors for the main landing gear and the tilted support rods. The skeleton, the main girder, and the skin of the basic structure are all made of aluminum alloys. The windshield and windows of the passenger/cargo cabin are made of organic glass, and the deck of the passenger/cargo cabin and the rear luggage compartment are of honeycomb structure. The passenger/cargo cabin is 4.82 m long, 1.46 m wide and 1.7 m high, and its floor loading is 750 kg/m^2. The floor loading of the luggage compartment is 488 kg/m^2.

The wing has a double-spar box type metallic structure with a rectangular planform. It uses an advanced high lift-to-drag ratio GA-0417 airfoil, and has dihedral of 1°41', an aspect ratio of 8.62, and a wing area of 34.27 m^2. The skin of the wing is bonded to the main girder; the other joints are riveted.

The tail assembly consists of a trapezoidal vertical tail and a rectangular horizontal tail; both of which are of metallic structures. The skin of the forward section of the elevator and the rudder is 0.6 mm thick; over the rear section, it is 0.3 mm thick. On the geological model of the Y-12I, the elevator and rudder are equipped with counter-weights made of cast-bronze material. The trim tabs of the elevator and the rudder are operated by motor-driven mechanisms.

The power plant of the Y-12I consists of two Pratt and Whitney turboprop engines installed on the inboard sections of the wing; each engine can produce 500 shaft horsepower.

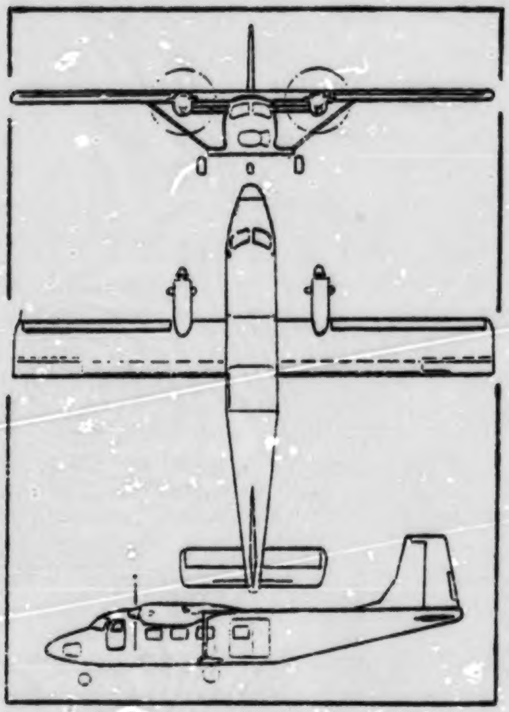
The nose gear is attached to the third frame of the fuselage; the main landing gear is attached to the forward beam axle of the subwing. The nose gear is of column design, and the main landing gear is of swing-arm design; both are equipped with hydraulic dampers. When the damping column of the front landing gear is compressed by 40 mm, the upper and lower cams of the positioning mechanism become completely disengaged, and the wheel is free to rotate about the damping column. The shimmy damper has a piston type design; it prevents shimmy vibration by passing high-speed, pressurized hydraulic fluid through the damping holes.

The aileron control unit in the main control system uses a mixed type mechanical drive. The elevator control unit uses double steel cables; both the elevator and rudder control units use soft/hard type mechanical drives. In the auxiliary control system, the fully retractable Fowler flaps are controlled using a mixed electrical-mechanical drive. The manual control unit of the airplane uses a disc type dual control device with Y-column structure. The foot control unit uses a four-bar linkage with adjustable foot pedals. The pilot and co-pilot each has his own control; they can operate the controls either simultaneously or individually.

Technical Performance

Based on large amount of ground test and flight test results, the design of the Y-12I aircraft has proven to be successful. The aircraft has superior flight performance and good operating results; it is safe, reliable, and efficient.

The technical data of the Y-12I are as follows: wing span--17.235 m, length--14.86 m, height--5.575 m; design take-off weight--5,000 kg, empty weight--3,000 kg, maximum payload--1,700 kg, maximum fuel capacity--1,230 kg; maximum cruising speed (H = 3,000 m)--328 km/hr, operational speed--180 km/hr, climb rate (H = 0 m)--6.5 m/sec, single-engine climb rate (H = 0 m)--0.6 m/sec; cruising altitude--3,000 m, single-engine ceiling--1,750 m, dual-engine ceiling--greater than 7,000 m, take-off distance--234 m, landing distance--219 m, range--1,440 km, endurance--6.9 hours.



3012/6091
CSO: 4008/33

APPLIED SCIENCES

BRIEFS

SILICON CARBIDE FIBER RESEARCH--Changsha, 28 October (XINHUA)--Some results of laboratory research in silicon carbide fiber and its basic material, polycarbo-silicane [ju tan qui wan 5112 8955 8944 7909], passed state appraisal in Changsha on 27 November. The achievement has opened up a new field for China in silicon-carbon polymer chemistry. The achievement was made by the No 505 Research Office of the Fifth Department of the University of Science and Technology for National Defense after five years of painstaking research, with the support of other concerned organizations. [Excerpt] [Beijing XINHUA Domestic Service in Chinese 0744 GMT 28 Oct 85 OW] /12913

CHINESE CHARACTER COMPUTER PROGRAM--Beijing, 17 December (XINHUA)--A computer program for processing Chinese character information was developed by Zheng Yili, a linguist who has devoted his whole life to the study of Chinese characters. The program, named "26-Key Coding Program for Chinese Characters," divides the 6,763 commonly used Chinese characters into 26 main groups and 69 subgroups by their roots, and codes them accordingly. Using the program, a semiskilled operator is capable of typing 60 characters per minute. [Summary] [Beijing XINHUA Domestic Service in Chinese 1157 GMT 17 Dec 85 OW] /12913

LASER SURVEY INSTRUMENT--Beijing, 3 November (XINHUA)--China has successfully tested a new type of laser survey instrument. Capable of accurately surveying objects within a range of 1 to 75 meters, the instrument is suitable for use in aircraft manufacturing, shipbuilding, energy, and large high-precision machinery processing. [Summary] [Beijing XINHUA Domestic Service in Chinese 1513 GMT 3 Nov 85 OW] /12913

NEW OPTICAL MATERIAL--Beijing, 22 December (XINHUA)--A new optical material, capable of changing an invisible infra-red laser beam into visible green has been developed by the Artificial Crystal Research Institute under the State Administration of Building Materials Industry. The material, named "potassium oxygenic titanium phosphate," [lin suan yang tai jia 4340 6808 8638 7835 6905] is an artificially-made single crystal, and is ideal for developing laser telecommunications from submarines, exploring continental shelves, and distance-measuring by man-made satellites. It was learned that only two countries, China and the United States, had developed such crystals which can be practically used in laser devices. [Summary] [Beijing XINHUA Domestic Service in Chinese 0306 GMT 22 Dec 85 OW] /12913

CSO: 4008/1034

SCIENTISTS AND SCIENTIFIC ORGANIZATIONS

MEDICAL JURISPRUDENCE SOCIETY ESTABLISHED

OW311845 Beijing XINHUA in English 1456 GMT 31 Oct 85

[Text] Zhengzhou, 31 Oct (XINHUA)--The Chinese Medical Jurisprudence Society was set up at a five-day meeting which ended today in Luoyang City, Henan Province.

The Society is aimed at developing the country's medical jurisprudence and boosting cooperation with foreign academic institutions in the field, according to Li Boling, chairman of the Society.

It will also open seminars and help tackle problems in the practice of medical jurisprudence, he added.

The regulations of the Society were passed at the meeting, which was attended by 300 specialists. Over 300 academic papers were also presented at the meeting.

China's medical jurisprudence has a long history. "The washing away of wrong" by the practitioner Song Ci in 1247 is believed to be the first work on medical jurisprudence in the world. The book was later introduced to many foreign countries.

China at present has over 7,000 practitioners in the field. There are also more than 500 students majoring in this subject in colleges and universities.

The country has spent 21 million yuan since last year on opening medical jurisprudence departments and courses in six of its key institutions of higher learning, Li noted.

/12712
CSO: 4010/1027

Acoustics

VIBRATION AND NEAR SCATTERING FIELD OF IMMERSED RECTANGULAR ELASTIC-VISCOELASTIC COMPOSITE PLATE IN AN UNDERWATER SOUND FIELD (I)--ANALYSIS OF RECTANGULAR COMPOSITE PLATE SYSTEM

Beijing SHENGXUE XUEBAO [ACTA ACUSTICA] in Chinese Vol 10 No 6, Nov 85
pp 344-357

[English abstract of article by He Zhaoyong [0149 4373 6978] of Harbin Shipbuilding Engineering Institute]

[Text] Based on the theory of elasticity, according to the least elastic energy and variational method, the neutral plane position of the elastic composite plate system is determined. Then, the governing equations for the flexural vibration of composite elastic-viscoelastic laminar plates are derived.

It is shown that the governing equations and boundary conditions of this composite plate system are similar to those of thin plates if the equivalent rigidity, Poisson's ratio and surface-mass density are used instead of the parameters in equations and boundary conditions.

The general solution for bending motion of this plate system is given by the normal mode analysis method and Fourier analysis. As an example, a simply-supported, rectangular composite plate system is presented. The equivalent rigidity, Poisson's ratio and surface mass density for bilaminar plate systems with steel as the base plate coated with rubber, plastic or a ceramic layer are numerically calculated. The damping constant, resistant coefficient and natural frequency for different vibration modes of this system with edges simply-supported are also calculated.

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ANGULAR DISTRIBUTION OF THE SOUND FIELD IN SHALLOW WATER

Beijing SHENGXUE XUEBAO [ACTA ACUSTICA] in Chinese Vol 10 No 6, Nov 85
pp 358-364

[English abstract of article by Zhu Baixian [2612 2672 6343] of the Institute of Acoustics, Chinese Academy of Sciences]

[Text] The field of a harmonic point source in layered media has a certain angular distribution. Although by ray theory the angular distribution of the sound field can be calculated for a given receiving point, the effect of the frequency on the angular distribution function and the sound field in the shadow zone cannot be calculated. In this paper the angular distribution of the sound field in a layered media is discussed using the normal-mode theory, and the general expression of angular distribution function and attenuation law for directional reception are obtained. The results given can be used for calculating the sound field in the shadow zone and they represent the influence of the frequency on the sound field. The channel of the underwater sound and the effect of the signal detection in it are investigated, the results of which can be used in choosing the optimum receiving direction. The numerical calculations are produced for the given medium model, and an analysis and discussion are given.

EXPERIMENTAL STUDY OF VISCERAL INJURIES OF RABBITS RESULTING FROM NOISE EXPOSURE

Beijing SHENGXUE XUEBAO [ACTA ACUSTICA] in Chinese Vol 10 No 6, Nov 85
pp 365-371

[English abstract of article by Qian Weiquan [6929 4850 2936], Zheng Suxian [6774 4790 6343] and Huang Duansheng [7806 4551 3932], et al., of the Institute of Space Medico-Engineering, Beijing; and Wei Wen [7614 2429], et al., of the Institute of Acoustics, Chinese Academy of Sciences]

[Text] This paper describes the characteristics of visceral injuries of rabbits exposed to a wide-band noise field of 168 dB sound pressure level. The experimental results demonstrate that the injury sites are dependent on the posture of the animals. For animals in free or prone posture the most vulnerable organ is the lun, which opens to the outer atmosphere, and next are the hollow organs, such as the stomach and the intestines. For animals exposed in supine posture the heart is usually as seriously injured as the lungs, and parts of the stomach, intestines and liver which are situated near the abdominal wall also show some significant injuries. Our experimental results reveal that the primary pathological cause organ injuries is the mechanical effect of the sound waves.

9717
CSO: 4009/31

Electronics

A NEW KIND OF PULSE-TO-PULSE AGILE CODES AND THEIR STATISTICAL PULSE COMPRESSION CHARACTERISTICS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 4, Jul 85 pp 1-8

[English abstract of article by Su Zefeng [5685 3419 1496] of Southwest China Research Institute of Electronic Technology, Chengdu]

[Text] The radar signal design and signal processing are investigated comprehensively to obtain the optimum statistical pulse compression characteristics (SPCC). First, the SPCC of a code set with L codes is studied that is obtained by truncating a cyclic PN code in a fixed step length with the truncated length L being equal to the code length of the cyclic PN code and transmitted in turn to implement the code agile in pulse-to-pulse (CAPP). The general expressions of SPCC for the kind of codes mentioned above are derived. The peak ratio of the main-lobe to side-lobe (RMS) of SPCC within the pulse repetition period (PRP), referred to as RMS in the near region, is greater than L, but is very small outside the PRP, which is referred to as RMS in the far region. Next, in order to improve the RMS of SPCC in the far region for the code set mentioned above, a code set truncated from a cyclic PN code in a stochastic step length is proposed with the truncated length L. Although these agile codes have a good RMS of SPCC in the far region when compared with that of the previous one, these agile fashions are considerably fewer than those with a fixed step length. Finally, a new kind of pulse-to-pulse agile code (NKPPAC) and their SPCC are investigated by means of computer simulation. The RMS in the near region for the NKPPAC is the same as the one the truncated PN code set gave, and that in the far region is also greater than L, except for a very few code sets with a particular code length L in a particular agile step length. Even so, in the last case the difference from L of RMS of SPCC in the far region is also very small. If the code length L is sufficiently large, the high RMS of SPCC required can be achieved without weighted processing. This will lead to simplification of the hardware for engineering implementation. The hardware experiment proves that the NKPPAC generators are very simple, an asset for engineering applications. (Paper received in December 1984; finalized in March 1985.)

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THEORY OF OPEN RESONATORS FORMED BY IRREGULAR WAVEGUIDES

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 4,
Jul 85 pp 23-29

[English abstract of article by Xu Kongyi [1776 1313 5030] and Liu Shenggang [0491 4141 4854], Chengdu Institute of Radio Engineering]

[Text] A new theoretical method for analyzing open waveguide resonators is given. In order to overcome the difficulty caused by different boundary conditions on each end of the cavity, an unknown separation surface of fields is set up in this method. In this way analytical solutions for the fields, including diffraction output power, are obtained. All the theoretical results agreed satisfactorily with the experiments.

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A TAYLOR PATTERN FAMILY FOR APERTURE ANTENNAS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 4, Jul 85 pp 30-36

[English abstract of article by Fang Tongcheng [2455 0681 1004] and Li Junpei [2621 3182 3099] of Nanjing Research Institute of Electronic Technology]

[Text] In order to study the inherent relationships for the most often used patterns and find new patterns a new synthesis technique, the Taylor Pattern Family (TPF) for aperture antennas, is developed. The TPF is introduced and its zeros are corrected by the conventional Taylor Pattern. For the TPF, its constructions, fundamental pattern family and visual coordinates (S, α_1, α_2) are discussed. The new parameter α_1 and the corrected σ are of importance to the analysis and synthesis of monopulse antennas for low sidelobes. Two examples of the TPF are described. (Paper received December 1983; finalized October 1984.)

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A NEW CIRCUIT MODEL OF THE HARMONIC OSCILLATOR

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 4,
Jul 85 pp 36-41

[English abstract of article by Wu Zhengde [0702 2973 1795] of Chengdu Institute of Radio Engineering]

[Text] Based on the dynamic Van der Pol nonlinearity model, the second and third harmonic oscillators are studied using the describing function method. The electrical characteristics and tune sensitivity of the fundamental frequency and harmonic loops under the optimum conditions are discussed. The basic principles for designing the harmonic oscillator are proposed. In addition, a new circuit model with good tunity and highest output power is given. (Paper received January 1984; finalized August 1984.)

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CALCULATION OF THE SHIFTED FOCAL AXIS ANTENNA BY SPHERICAL WAVE THEORY

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 4, Jul 85 pp 56-64

[English abstract of article by Li Zhenxing [2621 2182 5281] and Mao Yukuan [5403 0060 1401] of Northwest Telecommunication Engineering Institute, Xian]

[Text] The scattered field from the subreflector, the secondary radiation patterns and the efficiency of the shifted focal axis antenna are analyzed by means of spherical wave expansions, diffraction theories, etc. The calculated results are in good agreement with the experimental ones, and show that these formulas are effective for engineering design. (Paper received January 1984; finalized October 1984.)

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EXACT DESIGN OF SWITCHED-CAPACITOR FILTERS USING SIGNAL-FLOW GRAPHS AND TWO-INTEGRATOR-LOOP

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 4, Jul 85 pp 64-67

[English abstract of article by Zha Qiangzhong [2686 1730 0022] of the Department of Electrical Engineering, Chongqing University]

[Text] A new technique for directly designing bilinear switched-capacitor filters using signal-flow graphs and the two-integrator-loop is described. This simple and flexible method is applicable to all types of SCFs. The resulting circuits have low sensitivities both to element value variations and to parasitic capacitances. (Paper received January 1984; finalized August 1984.

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STUDY OF I-V CHARACTERISTICS IN InGaAsP/InP DH LED'S

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 4, Jul 85 pp 108-111

[English abstract of article by Zhang Guicheng [1728 2710 2052], Chen Ruizhang [7115 3843 3864] and Yang Linbao [2799 2651 1405] of Shanghai Institute of Metallurgy, Chinese Academy of Sciences]

[Text] I-V characteristics of InGaAsP/InP DH LED's are investigated, especially the dependence of V_f, V_0 and V_B on the active layer's acceptor concentration, the location of the p-n junction, the dopant for the p-InP confining layer, the heat sink temperature and the fabrication techniques, as well as the dependence of I-V characteristics on the light output power and the spectral characteristics. Reasons are explained for the devices having different I-V characteristics. (Paper received February 1984; finalized September 1984.)

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9717
CSO: 4009/1023

THE FAMILY PROBLEM OF QUARKS AND LEPTONS IN TWO KINDS OF COMPOSITE MODELS

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 9 No 6, Nov 85 pp 660-668

[English abstract of article by Yang Xin'e [2799 2450 1230] of the Department of Physics, Tianjin University]

[Text] Two kinds of $SU(3)_{sc} \times SU(N)$ composite models (model A and model B) of quarks and leptons are suggested to solve the family problem. The constituents (preons) of the models are two types of massless spin-1/2 fermions which belong to (3,N) and (3,N*) representations of the gauged symmetry group $SU(3)_{sc} \times SU(N)$. Applying the Fermi principle to three-preon supercolor-singlet composite fermions and according to the models' requirements (the fermions in one family originate from the same representation of SU(N) and belong to the same representation of the horizontal gauge group), one obtains the family-number of $SU(3)_{sc} \times SU(N)$, where $SU(3)_{sc} \times SU(6)$ and $SU(3)_{sc} \times SU(5)$ of model A predict three and five generations respectively.

ELECTRO-WEAK UNIFIED THEORY--A MODEL IN SU(3) x U(1)

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 9 No 6, Nov 85 pp 679-686

[English abstract of article by Chen Shihao [7115 0013 3185], Northeast Teachers' University]

[Text] An electro-weak unified model based on the SU(3) x U(1) group is suggested which is left-right symmetrical and assumes the same interactions of neutrinos (or antineutrinos) with charge leptons and antilepons before spontaneous symmetry breaking. It is anomaly free and $\sin^2\theta_W \lesssim 1/4$ can be derived. The difference between the model and the Weinberg-Salam model is very small in the low energy range. The lepton number is generalized to the lepton charge. It is proved that only the lepton charge is strictly conserved and the individual conservation of the lepton number of every generation of leptons is held only approximately. The quarks not only have baryon numbers and charges but also lepton charges. This model predicts processes $\mu_R^- \rightarrow e_R^- + \nu_{eL} + \nu_{\mu R}^c$, $e_L^- + e_R^- \rightarrow \mu_L^- + \mu_R^-$, etc.

A METHOD FOR CALCULATING PHOTON STRUCTURE FUNCTION IN DEEP INELASTIC SCATTERING

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 9 No 6, Nov 85 pp 697-702

[English abstract of article by Lu Jingxian [7120 2529 6343] of the Institute of High Energy Physics, Chinese Academy of Sciences]

[Text] This paper discusses the behavior of the photon structure function, considered to be a superposition of a hadronic and a pointlike component. The pointlike component is calculated in the quark parton model. The hadronic part is calculated in the vector dominance model. The valence quark distribution function of ρ^0 is assumed to be the same as that of π^0. The π^0 valence quark distribution function is represented by an analytic expression in the leading logarithm approximation from the Altarelli-Parisi equation. Results obtained are in agreement with experimental data.

THE STOCHASTIC EQUATIONS IN THE LATTICE GAUGE FIELD THEORY AND THE SCHWINGER-DYSON EQUATION FOR THE WILSON LOOP VARIABLE

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 9 No 6, Nov 85 pp 703-711

[English abstract of article by Xue Shesheng [5641 4357 3932] and Xian Ding-chang [0405 7844 2490] of the Institute of High Energy Physics, Chinese Academy of Sciences]

[Text] The method of stochastic quantization is applied to the lattice gauge field theory and the Langevin equations for the link and Wilson loop variables are established for the U(N) and SU(N) cases. The relationship between the Langevin equation and the Schwinger-Dyson equation for the Wilson loop is discussed.

ROTATIONAL MODEL AND HIGH ENERGY SCATTERING

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 9 No 6, Nov 85 pp 712-717

[English abstract of article by Zhang Yushun [1728 4416 7311] of the Institute of High Energy Physics, Chinese Academy of Sciences]

[Text] In this paper the differential cross sections of the inelastic scatterings of protons of energy ~1 GeV on ^{152}Sm, ^{154}Sm and ^{176}Yb are calculated using the collective coordinate and high energy cluster scattering theory, and using an axially symmetric rotational model and an optical model with a Woods-Saxon potential. The results are in agreement with experimental data.

RESEARCH ON ELASTIC SCATTERING INDUCED BY 7-5 MeV/A ^{14}N ON ^{59}Co AND ^{51}V

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 9 No 6, Nov 85 pp 718-722

[English abstract of article by Shen Wenqing [3088 2429 1987], Zhu Yongtai [6175 3057 3144] and Zhang Yuhu [1728 3768 5706], et al., of the Institute of Modern Physics, Chinese Academy of Sciences; and Zheng Zhihao [6774 1807 6275] of Lanzhou University]

[Text] The energy spectra and angular distributions induced by 7-5 MeV/A ^{14}N on ^{59}Co and ^{51}V are measured using a semiconductor detector. The atomic numbers and quantities of the contaminated heavy element are determined. The angular distributions of the elastic scattering are fit using the General Fresnel model. The possibility of extracting the quasi-elastic cross section from the fitting procedure is discussed.

LOW ENERGY CROSS SECTION MEASUREMENT OF D-D AND D-T REACTIONS*

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS]
in Chinese Vol 9 No 6, Nov 85 pp 723-735

[English abstract of article by the First Research Group, First Research Division, Institute of Modern Physics, Chinese Academy of Sciences]

[Text] The cross sections of a deutron-deutron reaction for deutron energy from 15 keV to 150 keV and of a deutron-tritium reaction for deutron energy from 13.8 keV to 114.3 keV were measured using the process of passing a deutron and tritium beam into a gas target formed by a differential pumping system and two capillary pipes. Experiments in two step-angular distribution measurement and absolute differential cross section measurement were performed at three Cockcroft-Walton generators with terminal voltages of 50 kV, 150 kV and 300 kV. Empirical fit of the D-D reaction data to the Gamow formulae and a comparison od the D-T reaction data with BWE theory are given.

* This research was completed in 1970.

PHASE-SHIFT ANALYSIS AND GENERALIZED EIGENVALUE ANALYSIS OF THE d-α CLUSTER STRUCTURE OF ^{6}Li

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 9 No 6, Nov 85 pp 742-750

[English abstract of article by Zhao Xuan [6392 3763], Hou Renchang [0186 0088 9480] and Zeng Fanan [2580 4907 1344] of Shanghai Institute of Nuclear Research, Chinese Academy of Sciences]

[Text] By using the d-α cluster-structure wave function and the nucleon-nucleon (N-N) force containing a soft-repulsive core central potential and a spin-orbit noncentral potential, the $(1^+,0)$ ground state, $(3^+,0)$ first excited state, $(2^+,0)$ third excited state and $(1^+,0)$ fifth excited state of ^{6}Li are studied by phase-shift analysis and generalized eigenvalue analysis with single-channel resonating group method (RGM). The results show that, from the phase-shift and eigenvalue analyses, the ground state of Li is mainly an 1=0 d-α cluster-structure bound state, and the first, third and fifth excited states of Li are mainly (1,J)=(2,3), (2,2) and (2,1) cluster-structure unbound states, respectively.

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CSO: 4009/30

Radiation Protection

A SURVEY OF RADIATION PROTECTION FOR PARTICLE ACCELERATORS IN CHINA

Taiyuan FUSHE FANGHU [RADIATION PROTECTION] in Chinese Vol 5 No 6, Nov 85 pp 401-408

[English abstract of article by Song Shushou [1345 2579 4849] of the "Particle Accelerator Radiation Protection Regulations" Compilation Team]

[Text] This paper summarizes general aspects of radiation protection for 43 sets of particle accelerators in China, including radiation shielding, radiation safety systems, radiation monitoring, radiation accidents and radiation safety administration, etc. Some problems in radiation protection presented by particle accelerators are analyzed. It is recommended that they be paid attention to and solved soon.

TREATMENT OF LIQUID WASTES CONTAINING ACTINIDES AND FISSION PRODUCTS USING AN INORGANIC ION EXCHANGER--SODIUM TITANATE

Taiyuan FUSHE FANGHU [RADIATION PROTECTION] in Chinese Vol 5 No 6, Nov 85
pp 415-421, 408

[English abstract of article by Yu Ying [0205 3853], Lin Meiqiong [2651 5019 8825] and Fan Xianhua [5400 7359 5478], et al., of the Institute of Atomic Energy]

[Text] The laboratory-scale synthesis, analysis and exchange performance for actinides and fission products of an inorganic ion exchanger, sodium titanate, were investigated. The effect on the distribution ratio was also investigated for several cations and organic complex agents which might exist in nuclear fuel reprocessing high-level liquid wastes. It was found that the exchange capacity of sodium titanate was not changed after irradiation of up to 5×10^8 rad. The experiment on low-level liquid wastes from the Institute of Atomic Energy (10^{-6} Ci/L calculated as gross β activity) using synthetic sodium titanate showed that the decontamination factor of Sr was greater than 10^4 for a 180 bed volume effluent and no less than 10^3 for a 1180 bed volume effluent. After further decontamination of Cs and Co in anionic complex state with natural zeolite and macroporous anion resin respectively, the specific activity of liquid wastes reached 1×10^{-10} Ci/L, near the discharge level of 7×10^{-11} Ci/L.

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- END -

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1 March 1986

China Report

SCIENCE AND TECHNOLOGY

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SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

TAPPING POTENTIAL OF THOSE RETURNED FROM STUDY ABROAD

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENTIOLOGY AND MANAGEMENT OF S&T] in Chinese No 11, 12 Nov 85 pp 28-29

[Article by Li Tianhou [2621 1131 0624] and He Zhuo [0149 0587] of the Shenyang City CPC Committee Scientific Education Department: "Exploit the Potential of Talented People Who Have Gone Abroad for Study and Training, Develop and Import Intellectual Resources"]

[Text] According to an investigation of 22 institutions of higher education and 14 scientific research and design units in the Shenyang scientific education system, 54.5 percent of the 321 personnel who have gone abroad for study and training for a year or more were sent after the 3d Plenum of the 11th CPC Central Committee. Of this group, our survey focused on questions related to the work, study, life and implementation of related policies for 116 persons and sought out their opinions in a comprehensive way. Advanced S&T personnel accounted for 26 persons or 22.4 percent of these 116 study and training personnel, middle level S&T personnel for 80 persons or 69.0 percent and elementary level S&T personnel for 10 persons or 8.6 percent.

I. The Latent Function of Importing Intellectual Resources

Of the 116 personnel surveyed, 40 persons or 34.5 percent went to Japan for study or training, 46 persons or 39.7 percent to the U.S., 8 persons or 6.9 percent to Switzerland, 7 persons or 6.0 percent to West Germany and 13 persons or 12.9 percent to other countries. The results of the survey show that sending out talented people and bringing in intellect rapidly improved the intellectual levels of S&T personnel and brought them very quickly into the forefront of world science and technology. This sort of importation of intellectual resources not only saves time and provides quick results but also conserves on intellectual investments. Imports of technology generally are not the most advanced but the importation of intellectual resources can lead to continual creation of advanced technologies.

In terms of scholarly and professional levels, 10 of the 116 personnel who returned from study and training abroad ["returned personnel" hereafter] obtained doctoral degrees. Some of them even were lauded as "post-doctorates" abroad and some were invited to be "visiting professors." They have become valuable intellectual wealth for the nation after completing their studies and returning to China, and 40 percent of them are playing important roles. Six of the 116 returned personnel were approved as advisors for graduate students and 81 were advisors for masters graduate students, a total of about 75 percent. There were 35 persons responsible for important scientific research topics and most of the others undertook important educational and scientific research tasks and made definite achievements. There were 20 projects that obtained scientific research achievements awards at the provincial level and above, including six topics that reached advanced levels within China and four topics that reached advanced international levels.

The results of the survey show that the returned personnel are a formidable scientific and technical "shock brigade" that plays a leading role in educational and scientific research work. They have shown the precious value of importing intellectual resources and will be of inestimable utility in the strategic task of completing the "quadrupling" [of the total value of industrial and agricultural output by the year 2000].

II. Full Use of the Potential of Talented People Who Have Studied and Been Trained Abroad and Returned to China Remains To Be Achieved

It can be seen from the survey that although the returned personnel have revealed their latent functions, they have not been fully used. Only about 40 percent of them are playing a rather good role. It was learned from a survey of the stand taken by the personnel that only 4 of them or 3.4 percent feel happy about their work, study and living while 90 percent feel that although the efforts of the CPC Central Committee and CPC committees at all levels have made quite a bit of progress in work related to implementation of policies concerning intellectuals, they are not satisfactory. The main reasons include the following aspects:

1. A lack of a true understanding concerning the role of returned personnel

Some leaders understand the implementation of the policies simply as arranging for employment for returned personnel. There is a lack of serious research concerning the positions that returned personnel should be given before they can play their roles. Of the 116 returned personnel, 35 were placed in leadership positions at middle levels and above. Administrative work occupies 70 to 80 percent of their effort and time, which greatly weakens their scientific research and educational work. Some units have serious seniority problems. Those under 50 accounted for 80 percent of the returned personnel and 78 percent have middle or elementary level technical positions. The fact that they have "little seniority and are young" means that their professions are not put to use. There are no guarantees for manpower, materials or finances. They studies many things while abroad but cannot develop their work after returning to China, which is an enormous waste.

2. The existence of a "Leftist" bias toward intellectuals

Of the 116 people surveyed, 40 felt that the question of discrimination still exists. Just as Comrade Hu Yaobang pointed out in his report to the 12th CPC

Central Committee, "an erroneous viewpoint of neglecting education, science and culture and discrimination against intellectuals has been rather common in our party for a fairly long time." Some units are uneasy about the politics of returned personnel and feel that it is inevitable that they were subjected to several bad influences when abroad or at least that they are a political blank. This has stifled the ideas of returned personnel.

3. Irrational arrangements and utilization

The survey showed that the inability of returned personnel to integrate study and application is even more serious than for talented people trained in China. Of the 116 people surveyed, 23 persons or about 20 percent could not use the specializations and knowledge they had studied. A design academy engineer trained in Japan is an example. He specialized in research on basic theories of earthquake prevention in tall structures and is a valuable talented person in China's construction industry at the present time. After returning to China, however, it was arranged for him to take part in educational work at the Electronics University. This phenomenon of irrational utilization has led to serious losses in science and education activities and in scientific research and teaching, and it has made the returned personnel anxious.

4. Poor working conditions, backward scientific research measures, shortages of equipment and capital, inadequate matchups of personnel

Of the 116 people surveyed, 20 or about 17.2 percent wish to have time guarantees while 27 or 23.3 percent requested administrative expenditures. There were 31 people or 26.7 percent who wished to be matched up with assistants and 26 or 22.4 percent who had asked for additional equipment. Some 18 persons or 15.5 percent needed laboratories. The problems mentioned above were acutely apparent in the survey. An engineer at the Shenyang Casting Research Institute made major breakthroughs in Japan while engaged in research on iron-silicon system materials. There was no way to gather the 40,000 yuan in administrative expenses needed after returning to China so the work stopped. Many returned personnel said emotionally: "while abroad, we worked every second to do scientific research but we are helpless after returning to China."

5. A lack of support for scholarly activities

The returned personnel used their outstanding scholarly achievements to gain respect in foreign academic circles and to establish scholarly exchanges. All of the returned personnel wished to create the conditions to maintain foreign scholarly relationships and to make full use of this favorable conditions. Comments they added to the survey said that "science is flying ahead at present and knowledge is being renewed at an accelerated pace. We should be given the opportunity for frequent academic exchanges with foreign countries. Otherwise, we will "die" academically." However, most people lost the opportunity for relationships with foreign countries after returning to China.

6. Low wages, housing shortages, worries of trouble at home

Only 24 people or 20 percent of the 116 surveyed had [monthly] wages greater than 100 yuan while 80 percent received less than 100 yuan and 53 or about 45 percent of them less than 80 yuan. Ten of the returned personnel received doctoral degrees. Six of them are earning 78 yuan and have become known as "78 yuan doctors." One teacher who received a doctorate in Japan is engaged in research in the area of cardiovascular pharmacology but receives a wage of only 69 yuan at present. They said "we receive only a few bonuses and slightly higher wages, but our poor base and many debts mean that we still are difficult [poor] households."

The returned personnel have small houses. Some 92 percent of the 116 people surveyed were over 36 years of age and most of them have older people as well as children at home. Some 40 of them or 34.5 percent have no home or only a single room; 60 people or 51.7 percent lived in two rooms. Only 16 people or 13.8 percent lived in three rooms.

In addition, they also urgently demand a solution to the problem of knowledge renewal. Their professional and technical titles also were evaluated irrationally. Some prominent talented people with substantial scholarly achievements in the forefront of science recieved no increase in title, which has affected academic exchanges within China and with foreign countries and influenced their support of graduate students to train talented people. This has damaged the initiative of some of the returned personnel.

It can be seen from the results of the survey that many factors have affected the initiative of returned personnel. The largest and most apparent problem, however, concerns how to create working conditions for them, allow them to play their role to the fullest, make it possible for them to contribute the knowledge, intellect and capabilities that they have studied to the cause of socialist modernization and construction to the greatest degree, and make their greatest efforts to make the nation and the nationality wealthy and strong.

III. Opinions Concerning the Development and Importation of Intellectual Resources

We offer the following opinions concerning ways to make fullest use of the role of returned personnel and greatest use of imported intellectual resources:

1. Further implement policies concerning intellectuals. Leaders at all levels should have a profound understanding of the important role of talented people, who have returned to China from study and training abroad in the four modernizations drive. We must have full trust in them politically and allow them to have positions, responsibilities and rights in technical posts. In work, we should be active in creating the conditions for them and be conscientious in solving real problems for them so that they truly can play their roles.

2. Personnel whose specialization of study during their period abroad is not appropriate for the work they are engaged in after returning to China or who do not have substantial relationships should be permitted to move to units suited to their specializations and where they can play their roles fully. They should not be held back by the unit they are in for any pretext.

3. We propose that related departments establish scientific and technical experimentation and research funds for returned personnel, that they raise scientific research funds and that they have a certain amount of foreign exchange funds. The administrative expenditures needed for all scientific research projects set up by returned personnel and those with economic value can be allocated directly by the funding committee, with persons responsible for the projects controlling their utilization and financial departments serving only to investigate and supervise financial and economic discipline.

4. Adopt earnest measures for active creation and improvement of working conditions. Capital should be gathered from many places and we should be willing to spend money to purchase some advanced instruments and equipment. Make full use of and transform existing equipment. Actively develop cooperative activities for utilization of large scale sophisticated instruments and equipment in severe shortage. Encourage individuals to establish linkages with foreign countries to purchase instruments and equipment. Develop individual friendship relationships and make full use of any instruments, equipment and experimental materials that are available from foreign friends.

5. Academic echelons, scientific research groups and the appropriate assistants should be established for returned personnel who have rather high scholarly level and are engaged in research on major scientific topics. Their opinions concerning the composition of the personnel should be respected fully and we should not make rigid organizatinal arrangements.

6. Strive to release returned personnel from the tedious formalities of administrative activities. Those returned personnel with rather profound academic achievements, those who are responsible for important scientific research and educational tasks and those who really are not suited to administrative and managerial work generally should not be placed in administrative leadership positions. Returned personnel who already have been promoted to leadership positions also should strive to reduce as much as possible their administrative tasks to allow them to concentrate their efforts on doing good professional management work.

7. Improve and strengthen logistical work. Logistical personnel should establish an ideology of service to educational, scientific research and technical work, work conscientiously to serve scientific research and education work, and guarantee smooth progress in scientific research and educational work.

8. Have a full understanding of the value of knowledge, allow the labor of returned personnel to receive the compensation it should and improve their treatment in life.

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CSO: 4008/2043

NATIONAL DEVELOPMENTS

FANG YI ADDRESSES CAS CONFERENCE

OW020259 Beijing XINHUA Domestic Service in Chinese 1304 GMT 1 Feb 86

[By reporters Zhu Weixin, Zhang Jimin]

[Excerpts] Beijing, 1 February (XINHUA)--Twenty-two advanced collectives and 19 advanced workers who have distinguished themselves in scientific research, as well as 162 research groups that have achieved remarkable successes tackling key research problems during the Sixth 5-Year Plan were commended and warmly congratulated by Comrade Fang Yi at the opening ceremony of a work conference of the Chinese Academy of Sciences [CAS] today.

Addressing the meeting's opening ceremony, which took place at the Great Hall of the People, Comrade Fang Yi said that the CAS achieved fruitful results in serving economic construction and in ensuring steady development of basic research during the Sixth 5-Year Plan. He urged CAS comrades to continue to work hard in 1986, throw themselves into the great Seventh 5-Year Plan with even greater enthusiasm, and strive to achieve new successes for the CAS.

He pointed out: Being an important force in the nation's scientific and technological sphere, the CAS has the resources of organizing various branches of learning in conducting comprehensive research. The CAS should now shoulder even more important projects than during any other period in the past. It should be determined to accomplish some major projects with important bearing on the national economy and people's livelihood, qualitatively accomplish key state research projects, and make new contributions to the national eocnomic growth and scientific and technological progress.

Comrade Fang Yi stressed: It has been proven by ample facts that cooperation yields better efficiency, speed, and results. The CAS should freely establish all forms of cooperation with various industrial departments, institutes of higher learning, local authorities, and large and medium-sized enterprises. He said: The proposal jointly presented by a number of scientists at this meeting to strengthen the CAS's ties with large enterprises is a good one because it can further liberate productivity by removing regional and departmental restrictions.

Yan Jici, vice chairman of the NPC Standing Committee, and leading members of departments concerned were present at today's meeting.

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CSO: 4008/2059

NATIONAL DEVELOPMENTS

CHINESE ACADEMY OF SCIENCES ON SCHEDULE WITH PROJECTS

OW031602 Beijing XINHUA in English 1453 GMT 3 Feb 86

[Text] Beijing, 3 Feb (XINHUA)--Construction of several large scientific devices are proceeding on schedule at the Chinese Academy of Sciences [CAS].

An electron-positron collider, a research facility for heavy ion research, and a 2.16-meter-in-diameter astronomical telescope are three of the major projects being built by the academy which will be completed during the Seventh Five-Year Plan (1986-1990).

Work on the collider at the High Energy Physics Institute in Beijing began in October 1984 and will be finished in 1988. The electron-positron collider consists of five major parts: a linear accelerator 200 meters in length, a 240-meter-in-perimeter storage ring, a 400-ton detector, a synchrotron radiation laboratory and a computer center.

So far the tunnel for the linear accelerator and the building for the klystron, which is a devise consisting of ultra-high frequency electron tubes which vary the velocities of a stream of electrons, have been completed, according to an announcement made by the academy's planning bureau here today.

Chinese scientists have developed a prototype of the linear accelerator and other key equipment, including radio frequency oscillators, dipole bending and quadropole focusing magnets and klystrons.

Completion of the collider will promote China's research in high energy physics and study of synchrotron radiation, which deals with the origin of cosmic radio waves.

China's largest heavy ion research facility is being built at the Lanzhou Institute of Modern Physics in Gansu Province. The facility includes a sector focusing cyclotron, a 60-meter-long transport line, a sector separating cyclotron and an eight-terminal laboratory.

Construction of the facility started in 1978 and will be completed in 1988. The sector magnets are now being installed.

The facility will be used for basic research on middle- and low-energy heavy ion nuclear reactions, as well as atomic physics and material science.

The 2.16-meter-in-diameter telescope being produced by the Nanjing Astronomical Instrument Plant will be the country's largest. It will be installed at Hebei Province's Xinglong Observatory, attached to the Beijing Observatory. At present, China's largest astronomical telescope is 1.26 meters in diameter. Installation work for the new telescope is expected to be completed in 1988.

An official of the Academy's Planning Bureau told XINHUA that in the next five years, the Academy will complete a number of pilot projects on robots, bio-engineering and new chemical materials, a synchronous radiation laboratory at China's University of Science and Technology, a scientific data bank and information system, a millimeter-wave radio astronomical telescope in Qinghai province, and experimental biology and earth sciences stations.

He said the completion of these will promote China's basic research as well as national economic development.

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CSO: 4010/1029

NATIONAL DEVELOPMENTS

3,000 ADVANCED TECHNOLOGY IMPORTS PLANNED FOR 1986-88

Shanghai JIEFANG RIBAO in Chinese 27 Nov 85 p 1

[Article by Huang Huachu [7806 5478 0443]: "More Technology Imports Planned for 1986-88"]

[Text] The State Economic Commission has decided that in addition to the 3,000 pieces of technology imported from abroad during the past 3 years, China will import a similar number of pieces of advanced technology in the first 3 years of the Seventh 5-Year Plan to promote the technological modernization of Chinese industry.

Most of the several thousand pieces of technology and equipment imported in the last 3 years of the Sixth 5-Year Plan reached international standards of the 1970's and early 80's. They have broadened our technological thinking and vision, raised the technological level of industry, and enhanced our capacity for self-reliance. The next 3,000 pieces of technology to be imported will be more geared toward the major thrusts in our industrialization, based on the present circumstances and needs of our enterprises. They will include know-how and key installations to complement or help assimilate what we have imported in the last 3 years. They will be the technology for making some of the products in short supply, particularly basic parts and components. They will be technology which can help light, textile, and electrical machinery industries upgrade and modernize their products and earn more foreign exchange. They will be the technology of quality control, standards testing, and so on.

The State Economic Commission has demanded that extra caution be exercised in determining our imports, that centralized import planning be carried out, and that foreign exchange be tapped in a multitude of avenues. In addition, scientific research, design, standards, and patent departments must strengthen feasibility research.

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LU DONG ON IMPORTATION OF ADVANCED TECHNOLOGY

OW161228 Beijing XINHUA in English 1152 GMT 16 Jan 86

[Text] Beijing, 16 Jan (XINHUA)--A senior economic official today urged China's electronics industry to continue importing advanced technology from abroad and upgrading existing large- and medium-sized enterprises to produce more and better electronic goods.

Lu Dong, minister in charge of the State Economic Commission, told national and local officials attending an ongoing conference on the electronics industry here that imported technologies should be absorbed before efforts are made to develop China's own.

At the same time, he said, "considering its potentially important role in China's modernization drive, the electronics industry should maintain a faster speed of development."

Over the past five years, China's electronics industry has imported over 1,000 items of technology. One-third of the country's major electronics factories have been at least partially renovated. The annual growth rate of the industrial output value averaged 22.8 percent.

Lu said more attention should be paid to production of electronic computers, massive integrated circuits and other key products to bring them into mass production.

Between 1981 and 1985, China's electronics enterprises produced 1,500 mainframe computers, 65,000 microcomputers, 150 million integrated circuits, 35 billion electronic components, and 1.32 million meters and instruments.

Production of electronic consumer goods increased sharply. compared to the 1976-1980 period. Manufacturing of tape recorders, for example, jumped 22 times to 25 million and televisions seven times to 40 million.

To improve quality, Lu said, production of major electronic goods should aim at world standards. He suggested that by 1990 many should be at the advanced world level.

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NATIONAL DEVELOPMENTS

BENEFITS OF IMPORTING TECHNOLOGY DISCUSSED

Beijing ZHONGGUO KEJI LUNTAN [FORUM OF SCIENCE AND TECHNOLOGY IN CHINA] No 1, Sep 85 pp 42-44

[Article by Li Baoheng [2621 1405 1854]: "A Shortcut to Accelerating Our Technical Progress"]

[Text] To realize the strategic goals of our socialist modernization, we must rely upon advances in technology. If we do not base ourselves upon advances in technology, we cannot develop our production forces and become modernized.

So how can we accelerate our technical progress?

Importing technology is the road all developing countries must follow to accelerate technical progress. China, too, must self-consciously take this shortcut.

To import technology we must have an open-door policy, and must open up both internally and to the outside. Since our coastal cities have been opened, there have been remarkable advances in the importation of technology, especially over the last 2 years. Importation projects have grown abruptly, which has quickened the pace of the technical transformation of enterprises, has improved product quality, has increased the kinds of products, has raised the level of labor productivity and operational management, and economic results have been striking.

Actual experience in the coastal cities that have been opened has already shown that opening to the outside and importing technology is a shortcut to the acceleration of our technical progress, and that this national policy must be maintained over time, and certainly that we must not stop summing up our experiences nor stop improving.

At present, and regarding the importation of technology, there are some problems that we must look into, as well as earnestly resolve.

The first problem that warrants our attention is when we pay close attention only to the importation of equipment, not respecting the absorption of the technology.

The primary mode through which all areas in China are currently importing technology is the importation of equipment. Naturally, it is absolutely necessary to import certain key equipment or sets of equipment. However, the importation of technology is definitely not the same as just buying equipment. Right now, in the technology transformation projects of some provinces and cities, importing equipment (buying hardware) constitutes 99 percent of the activity, while importing technology (buying software) is only 1 percent, which has become a problem. This sort of problem occurs in the early period of importation, when it is perhaps unavoidable, but it requires prompt attention and conscientious resolution.

Japan after the war also depended upon the importation of technology to build itself back up. According to Japanese government statistics, in the 1950's Japan averaged an annual importation of 230 technical projects; in the 1960's it averaged 1,000 a year; and in the 1970's it averaged more than 2,000. By March of 1978, the Japanese government had imported 29,599 technical projects, coming from 40 countries and regions, but primarily from the United States and developed nations in Western Europe.

However, in the first half of the 1950's Japan imported just some key equipment and a few entire equipment systems, afterwards concentrating on the purchase of technical patents and design blueprints. In the early 1960's, the proportion of software that Japan imported had already reached more than 80 percent, and in the 1970's Japan further restricted the proportion of equipment imported (only a few percent). Why did Japan act this way? It is well worth our consideration.

The goals for Japan's importation of technology lay in promoting its technical progress. In the period from 1950-1975 Japan imported a total of 25,777 technical projects, and the cost of technical patent fees and fees for technical guidance totaled 5.73 billion US dollars. By the estimate of the Japanese government, had these projects been developed completely by the Japanese themselves, the necessary development expenses would have been $180-200 billion. This is to say that by importing technology the Japanese saved more than 95 percent of development expenses. The American Dupont Corporation spent $25 million to develop the nylon synthesis technology, with a development time of 11 years. Later, the Japanese Toyo Jinzoito Kokusai (artificial silk company) imported the technical patent for that technology for only $7 million, which was successful after 2 years of development and went smoothly into production.

We can see from this that when it came to importation, what Japan paid most attention to was not buying equipment but was the absorption and assimilation of advanced technology. The expenses used by Japan for absorbing and assimilating advanced technology was generally 2 to 3 times that of importing technology. During the period from 1955-1975, Japanese expenses for importing technology were 15 times higher, while expenses for research and development increased 74 times.

This goes to show that in importing advanced technology from abroad we must integrate with our own research and development, and with our own research and development as a base, closely integrate what is imported with absorption, assimilation, and innovation. At the same time that we import technology, we want to innovate on the basis of absorption and assimilation from the points of thinking and organization down to the action level of absorption and assimilation.

The post-war historical experiences of the Japanese steel industry are well worth our study. During the 1950's and 60's, the Japanese steel industry imported more than 300 technical projects from abroad, and of the six great technologies among them, those of materials pre-processing, high-temperature high-pressure blast furnace, ejection of heavy oil, the oxygen top-blown converter, continuous casting, and continuous rolling, all were imported from either Austria, the United States, France, or West Germany. On the basis of its absorption and assimilation, Japan transformed and synthesized these technologies, creating the Japanese convertor steel making technology and the continuous annealing technology, the rights to which were then sold abroad.

At present, China's situation of low level repeated importation of equipment is a common occurrence. For example, many provinces and cities have imported clothing production lines, which must also use foreign currency to import materials. Because clothing designs (software) cannot keep up, some clothing production lines have either often stopped or slowed down. The technology for this kind of production line is certainly not advanced, and it is difficult to export the products to earn currency. Or take for example household appliances like color television sets or refrigerators, for which many production lines have already been imported. Each year great quantities of components and spare parts must be imported, the necessary foreign currency for which is many times that of the imported production line. Since the products are chiefly for domestic sale, they are lacking in competitive capacity on the international market, earn little currency, and if this goes on, deficiencies in foreign currency will continue to increase.

Imported technology must certainly work toward the acceleration of China's technical advancement, industriously improving the quality of China's products, improving the labor production efficiency for enterprises, and enhancing the competitive capacity of Chinese products in international markets.

Of course, importing a few clothing production lines, color television production lines, and refrigerator production lines to satisfy the ever increasing material and cultural needs of the public at large, even to the extent of importing some clothing and household appliances, is also necessary. However, we ought not to unlimitedly and repeatedly import this kind of equipment and commodities. We must take control macroscopically, and that equipment that can only earn money domestically and that has no capacity to earn foreign currency on the international market, does not generally merit large volume repeated importation. Through market forecasts and resource surveys, some cities in Guangdong decided to not import refrigerator production lines, but to import the technology, to bring in foreign funding, and to run marble factories, granite factories, and concrete factories to develop the local resource advantages, using commodities to exchange for foreign currency and pay back foreign investment. This kind of technology importation is worth mentioning.

Overall, what should we import? What should we not import? We need accurate strategic thinking as a guide, definitely cannot afford to not be choosy about what we do and import blindly, importing whatever foreign countries have to offer. Each city that has been opened and each economic zone must carefully and painstakingly study its own developmental strategies, determine their own development directions and focus, proceed from their own development requirements, begin deep investigation and research into foreign advanced technology, and then import that technology with a well thought out plan. Then, energetically take up the work of absorption and assimilation. All of this before foreign things can be made to serve China and accelerate the progress of our technology.

In this new situation of abrupt development of revolutionary technologies, there is the possibility that the economic and technical gaps between China and developed nations will continue to expand. We should have a sense of urgency regarding the importing of advanced technology to hasten China's technical advance and toward strengthening the competitive capacity of Chinese products in international markets.

Moreover, we should be fully aware that truly advanced technology, especially the newest achievements to improve the technical fields, will not be able to be imported. In the view of developed countries, providing advanced technology to foreign countries is equivalent to digging one's own grave, and they will strive to stay 10 years ahead of us technologically. Therefore, the entire country, each city, and even each enterprise, must energetically enhance their own research and development, beefing up the research and development contingents.

Because of the limitations of our national strength, we cannot technically "completely catch up and surpass," but there are things we can do and things we cannot. The sophisticated technologies of fusion energy and space exploration are very important, of course, but their funding and manpower require a very strong real capacity, for which within this century China cannot gather its energies to tackle. It is not that we do not do it, it is that we cannot. Therefore, in these fields it would be hard to avoid an increasing technical gap with developed countries in the future.

To allow 1 billion people to live comparatively well-off lives, we must manufacture large quantities of good quality, low priced new products to satisfy the increasing needs of both urban and rural people in the areas of clothing, foodstuff, housing, and transportation. Presently, many material products needed by the public at large on a daily basis are far from being satisfactorily supplied, and the only way out is to depend upon technical advances, to take the shortcut of importing foreign advanced technology. Moreover, this technology is completely importable and our scientific and technical contingent is completely capable of absorbing and assimilating it.

Let's look at foodstuffs. Recently, Comrade Chen Yun pointed out that: "The people live day by day because of food, and if we provide nourishing, sanitary, convenient, and substantial foods for our people, this will be beneficial to our modernization." For these reasons, we must strive to import modern food production technologies and greatly develop a modern foodstuff industry. However, our existing foodstuff plants can be largely said to be mainly manual operations. They cannot provide nourishing, hygienic, convenient, and substantial foodstuffs for the public at large. Therefore, each operation and household must expend a great deal of time in providing three meals a day. The key to our developing a foodstuff industry having abundant resources and expanded markets lies in importing modern foodstuff production technology. There are still in China a large number of uncultivated resources that could be used, as for example pollen, (CI LI), (SHA JI), (YUE JU), etc., which are materials that can be used for various highly nutritious food products, and as long as we are good at importing advanced technology for their processing, those products are entirely capable of entering the international marketplace.

This shows that if when importing foreign advanced technology we can combine that with the resource advantages of our own country, then the products can possibly enter the international marketplace and have a competitive capability. For example, China is richly endowed with rare earth resources, and if we can import without delay new technologies that use rare earth elements to make new types of magnetic materials, as well as to use these magnetic materials to make small package, highly magnetic electrical machinery, then it would be possible to enter the international marketplace.

The world new technology revolution presses us to hasten our steps toward technical advancement, requires that we undertake a full scale restructuring of our economic system, and makes the Chinese economic system have an even stronger capacity to assimilate the newest, current scientific and technical accomplishments, to motivate scientific and technical advances, and to gradually create new production forces. The reform has already broadened the road for an open-door policy and for the importation of technology, which has proven that importing technology is beneficial to accelerating advances in China's technology, and that it is beneficial to developing socialist production forces. We should boldly and firmly move forward on this shortcut to accelerating technical advancement!

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NATIONAL DEVELOPMENTS

RADIO, TELEVISION PRODUCTION INCREASES

OW221420 Beijing XINHUA in English 1318 GMT 22 Jan 86

[Text] Beijing, 22 Jan (XINHUA)--China manufactured radios and television sets valued at 40.9 billion yuan (U.S.$12.8 billion) over the last five years, government officials said today.

Production grew at an average annual rate of 32.8 percent, reaching more than half of the electronics industry's overall output value, they said.

According to statistics from the Radio and Television Bureau of the Electronics Industry Ministry, last year alone the industry produced 14.3 million televisions--six times more than in 1980--and 10.7 million radio-cassette recorders--13 times more than five years before.

The Ministry also reported considerable growth in production of marine communication equipment, broadcasting transmitters, television signal translators, telephone switchboards and portable communication devices as well as microwave, satellite, telex, radio facsimile and cable communication equipment.

Over the last five years, China on its own has increasingly designed and produced complete communication systems--such as those needed on offshore drilling rigs--rather than manufacturing isolated items.

In addition, the country has developed several new devices for tracking and guiding satellites and missiles.

In the same period, China began a number of crucial projects, such as the building of its first color television tube factory, renovated one-third of its electronics production facilities, and imported several hundred items of technology to improve research and manufacturing. As a result, the diversity, quantity and quality of electronics products has increased substantially.

The technical level of some products has been raised to the international standards of the late 1970s and early 1980s. For example, color television sets average more than 1,500 hours of trouble-free operation. For radio-cassette recorders the average is between 1,000 and 2,000 hours.

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NATIONAL DEVELOPMENTS

OPINION ON IMPORTANCE OF S&T REFORM

Beijing RENMIN RIBAO in Chinese 14 Nov 85 p 5

[Article by Yu Weidong [0060 4850 2767] abridged from the original in KEXUE GUANLI YANJIU [RESEARCH INTO SCIENTIFIC MANAGEMENT], no date: "We Must Be Firm in the Restructuring of the Science and Technology System"]

[Text] I. If we are to solve the problem of the integration of science and technology [S&T] with economic construction, we must first solve the problems of principles.

For several years, the party working principles for science and technology have been in a process of adjustment and evolution. In March 1978, at the opening of the National Science Conference, Comrade Deng Xiaoping emphasized the view of Marxism toward science that "science and technology are forces of production," and to have linked science and technology directly with the development of production forces was the theoretical basis for adjusting the science and technology working principles. From 1980 through 1981, leading comrades in the Central Committee repeatedly pointed out that science and technology must develop in coordination with society and the economy, and that we were to take economic construction as our prime task. In April 1981, while making public the communique by the national science commission leading party group "A Report Outline Regarding Policies Toward the Development of China's Science and Technology," the CPC Central Committee and State Council pointed out that we: "will consider the development of the economy and of science and technology together with the development of society as a whole, and we will overcome the problem whereby there have been no links between them. Economic construction will depend both on social science and the natural sciences." "The categories of science and technology are many and they must serve all areas; but above all they must serve economic construction." In October 1982, Comrade Zhao Ziyang, while representing the party Central Committee and State Council at the National Science and Technology Awards Ceremony, made clear the strategic principle that economic construction must depend upon science and technology, and that science and technology must cater to economic construction. This policy of "dependence--catering to" explained the relation between economic construction in China and science and technology, and reflected the internal rules regarding economic construction and the development of science and technology. This principle is both a strategic principle to invigorate the economy and a strategic principle to develop science and technology. The problem now is how we will implement and carry out this strategic principle of the party.

II. Implementation of the strategic principles of the Central Committee will be a long term process, and if we are to truly solve the problem of the integration of science and technology with the economy we must proceed along all the four aspects of principles, policies, planning, and systems. In his speech before the National Science and Technology Working Conference, Comrade Deng Xiaoping pointed out that "We must now go further in the problem of the integration of science and technology with the economy. What I mean by `going further' is to say that after the problems of principles and consciousness have been solved, we must still solve the problem of the system." "A new economic system ought to be a system that is beneficial to technical advancement. A new system for science and technology ought to be a system that is beneficial to economic development. We must work along both lines, for it is possible that the long term separation between science and technology on the one hand and the economy on the other can have a satisfactory resolution." The resolutions passed by the Central Committee regarding restructuring of the economic system and the resolutions regarding restructuring of the science and technology system have manifested the spirit of "working along both lines" as expressed by Comrade Deng Xiaoping in this speech.

Regarding the resolution to restructure the science and technology system, the Central Committee has made four points of emphasis in the reform: 1) to change the funds allocation system for scientific research organizations. 2) to adjust science and technology structures, and to strengthen the development and research capabilities of enterprises. 3) to stimulate the commercialization of technical achievements, and to open up technology markets to suit the economic development of socialist commodities, which has been a big breakthrough for us in theory and in awareness regarding the achievements of technology. To forcibly open up the technology marketplace is a matter of extreme importance in the restructuring of the science and technology system, and is a powerful measure for opening the way for the achievements of technology to flow through the channels of production. 4) to change the personal affairs management system for scientists and technicians, and to create a social environment in which people will make the most of their talents. Restructuring the science and technology system is to release productive forces, and it is foremost to release the productive forces of science and technology. Scientists and technicians are pioneers in the new production forces, and what is most important at present is to give full play to the positive role of current scientists and technicians.

Some people have been concerned that in stressing the policy by which science and technology must cater to the economy, this will affect China's research in basic science and will affect the approach to key problems in the larger scientific research projects. And there are also people who are worried that after universal implementation of a compensated contract system for developmental research units and some applications research units, this will develop a attitude of quick success and instant benefit, which will affect the progress of medium and long term research work. It cannot be said that there is no merit in this concern. If we do not do this well, it is possible that we will generate these side effects to some degree. In the process of drafting the "Resolution," these problems were examined deeply and the document was revised 10 times. More than 170 people were organized into more than 10 investigative groups for investigation into special subjects. These groups solicited the opinions of more than 3,000 specialists, scholars, and leading cadre, and organized more than 2,000 people in a discussion of the draft document. At the National Science and Technology Working Conference held in March this year, there was also a diligent and thorough revision of the draft document. The "Resolution" has made appropriate provision regarding problems that could occur, as for example, in stipulating that we must give proper attention to the in-depth plans for scientific research, that we must continue to carry out planning and management for the major national projects, that we must test a science funding system for basic research, and that we must carry out an expenses responsibility system for research units in standards, measurements, observation, information, and environmental sciences, etc. By diligently promoting these provisions we can guard against arbitrary uniformity, can avoid generating all sorts of side effects, and can bring the task of restructuring the science and technology system onto a track of healthy development.

Restructuring the science and technology system is a formidable project that will require leading departments of all levels to enhance their leadership, to guide carefully, and also requires that each area, each department, and each aspect be of one heart and one mind and make a concerted effort. We believe that after constant practice, summation of experiences, advancement, and improvement, the task of restructuring China's science and technology system is certain to be successful.

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NATIONAL DEVELOPMENTS

ANALYSIS OF NEW S&T HIRING SYSTEM

Beijing ZHONGGUO KEJI LUNTAN [FORUM ON SCIENCE AND TECHNOLOGY IN CHINA] in Chinese No 1, Sep 85 pp 57-58

[Article by Wang Kang [3769 1660]: "Some Problems with the Hiring System"]

[Text] The resolution by the Central Committee regarding the restructuring of the science and technology system clearly pointed out that we must restructure the science and technology personnel management system, and that we can gradually try out a hiring system in research and design organizations and for higher level institutions. Before this, the hiring system had already attracted the attention and comments of scientific and scholastic circles, and had as well achieved excellent initial results at test sites at several units throughout the country. Of course, it needed more testing, and especially to bring forth a set of rather complete policies and methods based on testing over a much larger scale. The central authorities have now made the testing of a hiring system within a certain scope to be an important matter in the restructuring of the science and technology porsonnel management system, which has even more attracted the attention and explorations of various aspects. In this paper I present a few superficial views for the benefit of personnel studies and personnel management.

I. The Function and Purpose of the Hiring System

For a long time now we have treated the management of scientific and technical personnel the same as party and government cadre, using the same methods, namely, planned assignments, organized transfers, and administered management. For the past few years, although we have undertaken a few improvements and reforms based on the characteristics of scientific and technical personnel, the management system, and especially the administrative system, are still basically in the old modes and old models.

Putting a hiring system into effect is not only beneficial to further breaking up the communal pot and overcoming abuse of the "iron armchair," but also can play a determining and even irreplaceable role in advancing the reasonable movement of talent. This is because in implementing a hiring system each unit has the authority it ought to have for utilizing personnel, and it can overcome the currently commonly existing phenomenon whereby a person that a unit wants cannot be transferred in and people that the unit does not want cannot be transferred out. The hiring system can also strengthen the capacity for self transformation and self development by the units in the aspects of talent and intellect. Because scientists and technicians themselves will be given a certain amount of authority to select their working positions at the same time that a hiring system is implemented, this will get past the barriers of "unit or department ownership," and will be an opportunity to get work positions that will fully develop their own abilities and their contributions to the nation. Similarly, implementation of a hiring system will create a situation of competition for talent, which will both create a respect for knowledge and a respect for talent by all parties, and will also allow scientists and technicians to grow within competition, as well as give the opportunity for a few top-notch people to emerge from obscurity. Overall, putting a hiring system into effect under the guidance of national planning could greatly enhance the role of social regulation, strengthen the flexibility and vitality of the science and technology personnel management system, and could fundamentally change the ossified state where there is unity to the extent of suffocation and isolation.

II. The Nature of the Hiring System

First, it is not a system for the hiring of labor. The hiring system that we will employ is fundamentally different from the labor hiring system of capitalist countries. The nature of the capitalist hiring system is that the laborer (including either physical or mental laborers) do not own the means of production, and can only sell their own labor force as a commodity to the capitalists or capitalist groups who own the means of production. But our hiring system will be built on public ownership of the means of production, whether that employment is through national or collective units, and both the employee and employer are the joint owners of the means of production. Politically, too, they are both masters of society and of the nation. Both parties to hiring activities will use the means of contracts or employment agreements or employment documents to stipulate the individual responsibilities, authority, and benefits that must be complied with, where both parties are in completely equal positions.

At the same time, our hiring system is under the guidance of national planning. The contents of contracts and employment agreements must suit the requirements of national planning and national policy and laws. This will also ensure that our hiring system is socialist in nature and is not the capitalist labor hiring system.

Second, will we be creating a free movement of scientific and technical talent, or what is called the freeing up of talent movement? I do not think so. The superstructure that is the personal affairs and cadre management system was determined on an economic basis, and also serves it. Scientists and technicians are exploiters of the new production forces, and the scientific and technical labor force is an important component of socialist production forces. Therefore, the scientific and technical personnel management system is intimately connected with China's economic system. China's economy is a planned commodity economy and is not a market economy. In economic fields, planned guidance, regulation, and management are in dominant and controlling positions. The hiring system that will be an important part of the scientific and technical personnel management system must also be guided and managed by state planning. The state has provided for reasonable channeling, and demands that hiring activities must coincide with the requirements of channeling. The scientists and technicians needed by the larger economic construction, defense construction, and scientific research projects must in the main or to a great extent be assigned by planning, especially for those key elements among them for whom there must be planned deployment with guarantees, and the assignment of college graduates and students who study abroad on public funds, to ensure the proportional development of the national economy. Therefore, our hiring system is certain not to create an anarchical freedom of movement.

Third, our hiring system has provided for relations between individuals and groups regarding employment for scientific and technical labor through contractual or employment agreement modes, and has as well provided for relations between the state and groups and individuals in these aspects through the guidance of national planning and policies and laws. This has allowed for the close integration and the organic unification of the needs of national planning with the hiring authority that units ought to have and with a certain amount of say in the choice of work place by the individual. Therefore, the nature of our hiring system is that it is a system that serves a positive function for and management of scientific and technical labor (which of course is scientists and technicians). Because it regulates the relations involved in the utilization of scientific and technical labor between the state, the group, and the individual, it is an important reform of the scientific and technical personnel management system.

III. Implementing the Hiring System is a Necessary Trend

We lack experience in running a hiring system under socialist conditions. We must proceed cautiously, make measured experiments, gradually expand them, and therefore perfect it. However, there is an objective basis for a hiring system, and it is a necessary trend. Therefore, at the same time that we are proceeding cautiously in a tactical way, we must be resolute strategically. The objective basis for the hiring system and its necessity are evidenced in the following:

First, the hiring system meets the requirements of China's economic system reform and the restructuring of the science and technology system. In implementing the reforms in those two systems, there will be in both cases an expansion of autonomy for enterprises and scientific research organizations, which will allow them to become relatively independent operational entities. The most important thing about autonomy is the authority for personal affairs. If they do not have the authority for personal affairs that they ought to have, they cannot resolve obstacles to the movement of talent. And when expanding enterprises, as well as developing scientific research organizations for research and partial applied research, it will be difficult to survive and plan for development in the competition of commodity and science and technology markets, and it will be hard to take on the responsibility for the particular profits and losses and for independent operation. Because of the competition in commodities (be they material or intellectual commodities), what is at the root is competition between talents. Also, the new world technology revolution is just now exploding, where renewal of commodities and technology is quickening daily, a challenge China is just now facing. Enterprises and research organizations must have a flexible response to this, and making use of the rightful authority over personal affairs, must constantly and in good time improve their own personnel and intellectual structures and strengthen the competitive capacity of products. The hiring system is a good means by which to meet the demands of this trend.

Second, the hiring system conforms to developing trends and demands in modern science. The trends in modern science toward both high degrees of differentiation and high degrees of synthesis demand that scientists and technicians expand their knowledge on that basis, that they constantly renew their knowledge and derive new academic theories and that research organizations and relevant units and departments undertake alignment and realignment by various classifications and on various levels based on the needs of scientific and technical development and in the aspects of talent structures, specialist structures, and intellectual structures. By putting a hiring system into effect, we can completely break out of the situation by which there is separation and barriers between particular departments and particular units. This will allow them to change from an isolated form to one that is open, which will accelerate the rational movement of talent, put a stop to "inbreeding" and ideological ossification, and develop "cross breeding of superiorities" and an innovative spirit.

Third, the hiring system has been determined by the characteristics of scientific and technical labor. Scientific and technical labor is a complex and creative mental labor. Its demands on the subjective factors of the interest levels and aspirations of the scientists and technicians themselves as well as on the objective conditions of working conditions and environment (including having reasonable intellectual structures and harmonious social relations) are much higher than for general physical labor. These subjective and objective conditions often have a decisive influence on the motivation and creativity of scientists and technicians. For example, some materials indicate that if scientists and technicians lack interest in their work, they can only operate at from 20 to 30 percent of their abilities. Of course, interests and aspirations can be changed. Those interests and aspirations that do not suit the demands of society and the nation ought to be dredged and corrected, but we should respect the proper aspirations and interests of scientists and technicians to more fully develop their creative capacities. Regarding the working conditions and environment needed by scientists and technicians, because of such factors as the rapid development of production specialization and division of labor, as well as technical innovation and the pace of the technology revolution, etc., to which is added the differences in the stages of maturity of scientists and technicians, things often happen because of people, or events, or the times, which makes them extremely complex and varied. Consequently, reasonable movements must proceed through unblocked channels that allow each person to achieve the required conditions and environment to the degree possible to fully develop their motivation and creativity.

Fourth, the hiring system suits the characteristics of Chinese labor. Our socialist system has public ownership of the means of production as its basis, where "laborers participate in labor as full fledged members of a society in joint ownership of the means of production" (Footnote) (for this and other quoted material, see Xue Muqiao [5641 2550 2890], "Studies on Problems in the Chinese Society and Economy," chapter 4, section 1). "The relationship between laborers and society is already the same as that of all members of a group with that group." "Their labor has a directly social nature." Which is to say, their labor has already combined to be the public labor of society, which then has a public quality about it. At the same time, and in another sense, labor is a means of an individual's particular life, and "society cannot but tacitly agree that differing capacities for work are owing to the natural peculiarities of individuals, and between society and individual laborers there must be an exchange of equal labor and equal commodities. Speaking from this sense, society and the individual laborer are possessers that differ." "After the means of production became public, traces like this of the old society are retained in great measure by individual laborers." Our hiring system--the hiring system under planning and guidance, will both provide for the individual scientist or technician the right to select a working place and for the relevant unit an autonomy in hiring people, and will also allow these rights to be placed under state planned guidance, regulation, and management. It will allow them to be maintained within the limits of what we discussed before as "a certain measure of" and "rightful," which is just the scope permitted by state policy and laws. To do it in this way will suit this nature of Chinese socialist labor where there is both a public ownership and a portion of individual ownership that has been retained. Consequently, there is historical necessity in the implementation of a hiring system.

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NATIONAL DEVELOPMENTS

HIGHER INSTITUTIONS IN S&T MARKETS DISCUSSED

Tianjin KEXUEXUE YU JISHU GUANLI [SCIENTIOLOGY AND MANAGEMENT OF S&T] in Chinese No 11, 15 Nov 85 pp 32-36

[Article by Tao Weijiang [7118 5898 3068]: "Some Reflections on the Function of Higher Level Institutions in the Technology Markets"]

[Text] Socialist technology markets have been formed through the state, groups and individuals, and the integration of autonomy in technology trade and the support of administrative departments. Their appearance breaks up the former science and technology [S&T] situation whereby science research, production, and the economy were divorced from each other, and they create the conditions in which to resolve the abuse of having "two skins" over science and technology and economic construction. Also they have accelerated the movement of talent and the circulation of technology. Technology that circulates in the form of commodities will also propel forward the restructuring of the science and technology system, as well as the dissemination, improvement, and transfer of science and technology. Therefore, the future of technology markets is expansive, and of great hope.

China's higher institutions have assumed the dual functions of training high level specialist technical personnel and of developing science and technology. There are at present more than 390,000 teachers and science research personnel, among which are one-half of this country's high level intellectuals. They are training 80 percent of the nation's graduate students, including both the social and natural sciences. The curriculum is complete and there is quick access to scientific and technical information, and there is as well the capability to organize more classes, to solve comprehensive major problems in science and technology, not to mention the ability to open up new products, new technology, and new techniques for small to medium enterprises. Up until now, higher institutions have been awarded 56 prizes in the natural sciences, which is 45.2 percent of those awarded in the natural sciences, and have been awarded 221 prizes for inventions, which is 24.4 percent of those given throughout the country.

However, on the other hand there are still problems when one compares the abundant real technical capability with the effect on the technology market of enterprises, companies, and research academies (institutes) and also its direct role on social and economic development. The author feels that applied science research in higher institutions should pay close attention to the following points.

I. Take the initiative in developing projects that are "short, balanced, and quick."

Currently, town and township and privately funded enterprises are developing quickly, but they remain technically weak and deficient in capital. They can only hope for large projects and large products but cannot attain them, even if larger enterprises have no particular interest in them. Especially for longer term projects and products, in fear that funds might lay idle too long, medium to large enterprises cannot keep up with changes in the market. Therefore, there is often the situation where medium to large enterprises are not very enthusiastic about the application and dissemination of scientific and technical achievements, but neither can small enterprises accept them (due to funding and technology factors); when the rights to technology are transferred, they dare not put up the capital, and even with the amount shared several ways they fear they will lose out, so it is difficult to make deals. But those small projects and small products where investment is small, development time short, results are quick, and there is a market for them, they just fit the demand and are taken up in a moment. The situation for higher institutions is often like this: some teachers are good at the theoretical research of basic science, and publish several papers each year; whereas, other teachers are better at taking on applied topics, and therefore, the science and technology management departments of higher institutions should emphasize both basic and theoretical research and research into applied topics. Based on market demands and market adjustments, they should organize those teachers who are good at dissemination of applications to take the initiative in developing short term, balanced, and quick projects. They can even adopt various formats of responsibility systems to attract teachers into taking up applied research, and directly serving social and economic development.

II. Earnestly aim at applications, be conscientious about substantial results.

Higher institutions ought to have intellectual reserves, and ought to have about 60 percent of their capacity engaged in the theoretical research of basic science, and based on the specialties of the school, can establish classes that focus on research, and within several years or a decade there will be breakthroughs to enter the ranks of international or domestic advanced levels. At the same time as this, about 40 percent of capacity should be put into actively taking the initiative to develop research into application topics, and to provide even more new products, new technologies, and new techniques for opening up the technology markets. This is also for accepting topics through various means that industrial departments encounter in actual production, that is, topics outside of planning. And, to constantly lead reserve knowledge or technology through horizontal relations to production departments, to feed technical difficulties from small to medium enterprises back to the schools, and to organize strength into making short term breakthroughs, allowing the potential of both parties to be fulfilled. When transferring the rights to technology, they should work toward perfecting one, then transferring one, and should evaluate the maturity of any technology from the point of view of society, the market, and applications. Trade may be done through an intermediary, which causes the market to be even more dynamic.

III. Directions should be flexible, policies should be implemented.

It is recommended that we draw on the experience of privately run technology institutes and science and technology development companies regarding the flexible and expedient, yet sound methods to develop technology markets. They are not limited to a certain field or a certain discipline, but do whatever the market needs. They do not need a state allocation system, nor do they need state allocated expenses, for on the one hand they take on research topics that are needed by the market, and on the other, organize their scientific and technical capacities. When things have been sized up, they act, when projects are completed, they let them go. Scientists and technicians get paid according to their efforts, and profits are distributed according to the degree of technical advancement and the degree of difficulty, as well as the degree of contribution toward completion of the project. This kind of management method is similar to the way some higher institutions plan application research topics based on disciplines, but is also different. Where it is similar is that things are tailored to capabilities; where it is different is where one person can measure the cloth to fit the body, but another does not do it that way. As the technology market develops, application development must be social, comprehensive, and flexible, and must accelerate cross fertilization and permeation of disciplines, as many projects will transcend departments and disciplines, and even the scientists and technicians that are involved in a project will be from different units and different categories. For these reasons, the technology markets have posed new demands for science and technology management in the higher institutions. Science and technology management includes the determination of research directions and planning, and the implementation of corresponding policies and measures. For a long time now, technology has been rather backward in many production fields, and the capability for large scale production of inexpensive, high quality products has been low. When the reasons for this are discovered, it is found that it is because intellectual labor and its material value have not been acknowledged, and even less has it been taken onto the track of commercialization. The appearance of technology markets and the commercialization of technical achievements have brought convenience to the implementation of science and technology policies.

As awareness of science and technology markets deepens, as long as directions are flexible and policies are implemented, the function of higher institutions in the technology markets will go up another story.

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NATIONAL DEVELOPMENTS

CRITICISMS OF S&T SITUATION IN HIGHER INSTITUTIONS

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENTIOLOGY AND MANAGEMENT OF S&T] in Chinese No 11, 15 Nov 85 pp 33-35

[Article by Tao Xinliang [7118 9515 5328], Office of Science Research, Shanghai Industrial College: "Some Viewpoints on Science and Technology Development in Higher Institutions"]

[Text] I.

Higher institutions rely upon the comprehensive technical advantages of their full and complete curriculum; they rely upon the comprehensive advantages of having many teachers, graduate students, and undergraduates; they rely upon the comprehensive information advantages from their vantage point among developments in technology and as a site for the collection and dissemination of science information; they rely upon the comprehensive development advantages from both science and technology service and talent in cultivation. With intellectual investment as the primary form, with technical output and talent cultivation as the primary means, they have become a major force in the cause of science and technology development, and have become a very vigorous and important power in the technology markets. But as the markets have abruptly risen and quickly developed, scientific and technical development in the higher institutions has both had its own advantages and characteristics, and its new problems.

1. They are faced with a fierce and unprecedented competition.

The forceful opening of the technology markets is manifest in the daily bustle of both buyers and sellers. On the one hand, with the abrupt rise of town and township enterprises, the rapid development of small to medium factories, and the great advances in economic construction, the requirements of scientific and technical achievements were expanded, and buying capacity and potential for technology by buyers increased. On the other hand, there were also great changes in the conditions of the sellers. Currently, the main powers actively putting technical achievements out on the technology markets are not just the science research organizations and the higher institutions; there are also various hierarchical science and technology development companies and centers that are horizontally aligned and non-governmental. And there are science association systems and systems of trade unions and technical associations, and some medium to large, and even small, factories have been setting up their own technology development departments or third production structures, all of which have joined the ranks of sellers in the technology markets. Industrial and mining enterprises have relied upon their own mature production technologies and abundant economic capacities, and through the channels of joint operations of production, technology output, sending out the processing of components, and providing materials and markets, they have become more vital in the technology markets; science associations and technology associations use the advantages of their talent networks and generous economic remuneration to attract a number of technicians to engage in science and technology development; private science and technology development companies even more rely upon their flexible operations and adaptable economic means to make the most of the potential in technical talent from everywhere in society, including the higher institutions. With so many forces out there, science and technology development in the higher institutions is faced with a precipitous battle line and very fierce competition.

2. There is an unfortunate tendency for an outflow of intellect.

Science research and development at higher level institutions has in recent years been struck in succession by three great influences due to the fact that the economic treatment of teachers is uneven. These have been jokingly called "the three waves." First: the gap in economic remuneration between science and technology development projects and projects from planning has grown steadily wider, the former because of deductions in net income, as well as because the proportion of the deductions has continued to rise (for example, at this school it has gone from 4 percent to 10 percent, and then to 17 percent), and the latter because they have not charged a single cent, and although some schools have adopted methods to "supplement internal deficiencies with outside help," these have been totally inadequate measures. The gap between the respective economic treatments of these two things has reached the point where some teachers have begun to "treat internal planning lightly, while emphasizing external planning." This has weakened the reasonable structures in science research in the schools, as well as the technical reserves for science and technology development. The second "wave": the majority of teachers are members of learned societies affiliated with science associations at all levels, and some years ago the science association system raised the portion of economic income from science and technology development received by individuals to 30 percent, and some have covertly tried to make it even greater. The tendency for some teachers to "emphasize science associations and neglect teaching" has caused a number of science and technology development projects that could have been taken on by schools to be shifted to science and technology associations at various levels, with the result that although the schools produce intellectual and material resources, the science associations obtain the material benefit and success. The third "wave": an upsurge in having work in addition to one's job, which some have called "the second occupation." Higher institutions used to have strict limitations on the question of teachers having concurrent work, as for example where it was ruled that sparetime part-time jobs had to be approved by the unit, and a proportion of the income obtained thereby was taken by the unit to take care of neighbors, etc. The "Resolution Concerning Restructuring of the Science and Technology System" once again pointed out that "with the prerequisite that scientists and technicians complete their own work and not infringe on the technical rights and economic benefits of their unit, they may engage in technical work and consulting services in their spare time, the income from which will go to themselves; if the technical achievements and internal technical materials and equipment of the unit are used, that unit must agree to said use, and a portion of the income turned over to the unit." Macroscopically, this measure is undoubtedly beneficial to developing the enthusiasm of scientists and technicians, and to accelerating advances in science and technology and in the development of economic construction. But from the school's view of microscopic management, this will be difficult to get a precise hold on. Teachers do not have a strict schedule, and they cannot, as can industrial and mining enterprises and research organizations, put a clear boundary around 8 hours. Intellect and knowledge is a formless valuable product residing within the minds of teachers, and it would be very difficult to simply put on clear marks like "this belongs to the unit" and "this belongs to the individual," much less where there is no clear provision that sparetime part-time work be put on the unit's records. Therefore, the schools find it difficult to know and determine whether the individual has violated the technical rights and economic benefit of the unit, so how is it to know whether internal technical materials have been disclosed? Schools cannot understand this. This has led to the tendency where some teachers have "emphasized the part-time job, while neglecting their own."

"Emphasizing external planning over the internal"; "emphasizing science associations over the schools"; emphasizing the part-time job over the primary one,", these three "waves" have resulted in a considerable portion of the intellect of schools being drained away.

3. There has not been a respect in fact corresponding to that in name.

Higher institutions are called one of the fifth route armies, but in fact have not received a sufficient amount of respect corresponding to that. It is, on the one hand, not like Chinese Academy of Sciences and local science academies, which can be supported by leading departments of all levels; nor is it like with research organizations in departments of the industrial and communications industries, that are supported by economics commissions, and in catering to factories have abundant financial resources for backup. When relevant leaders are dealing with large research development projects, what they think of first are the science academy system and affiliated research organizations; local industrial departments always think first that "rich waters should not flow to the houses of others," and confine their efforts to localities, taking care of research or development organizations run by the organization itself. It is always the case that only ungnawable hard bones and inedible chicken ribs and tails are turned over to the higher institutions.

Also, when some industrial departments import foreign advanced technology and equipment, they invariably neglect the high level capacity for assimilation and absorption possessed by higher institutions and science research organizations, and if they do not cast higher institutions to one side, they put them into secondary positions; higher institutions must cater to economic construction, but cannot "squeeze" into the higher echelons of scientific and technical development circles, into which advanced technology is absorbed and imported. They can only frustratingly chase after what is left, and cater to town and township enterprises with greater effort and take up work in the lower levels of science and technology development. If this goes on for a long time, it could create the following consequences: on the one hand, industrial departments will have lost the support of the scientific and technical capabilities of higher institutions, dragging down the process of absorbing imported technology and affecting the results from that absorption, even to the extent that they cannot give full play to the function of foreign advanced technology and equipment; sometimes, there is inappropriate repeated importation, which increases the expenditure of foreign exchange. On the other hand, higher institutions have therefore lost out on a valuable means of making contact with international advanced technology, and the level of science research cannot take advantage of an even greater boost, and sometimes it even happens that science research at higher institutions falls behind that of the level of technology already imported.

II.

How can we maintain and strengthen the capability for distillation of science and technology research at higher institutions?

1. Maintain the appropriate proportion of science and technology development funds, and increase encouragement economically. For the individual, there are four choices placed before the teachers at higher institutions: A. carry on in the capacity of the school, and when finished with a project, 14-17 percent of the net income should be deducted according to the particular provisions of each school as individual remuneration. B. Attach oneself to science associations, and deduct individual remunerations from 30 percent of net income according to science association provisions. C. Through the channels of private development companies, after completion, it is only necessary that they take 20-40 percent for management expenses, and the rest of the net income can be returned to individuals. D. Take on a spare time job directly with town and township enterprises or group units, the net income from which would nearly all go to the individual, or, as an alternative, he would receive a concurrent wage of the same amount. Among the four choices above, the deductions for the school itself are the least amount, but higher institutions still have the economic levers of increasing wages and promotions to maintain their momentum, attraction, and their distillation capacity. The proportion of money given to participants in technology development at higher institutions ought to be raised, or otherwise there will be a further increase in alienation, which would increase the tendency for intellect at higher institutions to flow away.

2. Provide for necessary procedures for managing concurrent jobs, and be more restrictive in discipline.

Seeing that teachers at higher institutions have no real 8 hour limitation, and that even including the quality of teaching and the amount of work done in research is a method that still lacks perfection and accuracy, therefore, when concurrent jobs are not approved by the units it can result in a few teachers "being on the job but their minds are elsewhere," a situation that cannot be controlled. It is recommended that provisions be made that sparetime part-time jobs by teachers at higher institutions be subject to approval by their units to more easily maintain the capacity for distillation of the science and technology development in higher institutions, and to reduce the outflow of intellect.

3. Enhance the self-building of higher institution science and technology development operations contingents.

Self-building of higher institution science and technology development operations contingents include two items. One is the improvement of the quality of the entire structure; the second is to arouse the enthusiasm of operations personnel.

Aside from deducting a certain percentage of economic income to encourage operations personnel in science and technology development, the prompt resolution of posts (academic rank) problems for operations personnel in science and technology development is an important measure for arousing the enthusiasm of those operations personnel. Operations personnel in science and technology development are just like people in research management and instruction management in that they are all professionals. Since we admit that management science is a large science, then why does management not share corresponding posts (academic rank)? We must change the erroneous conception that looks down on operations. Evaluation of the posts of specialized management workers ought to have different standards, should form a series of their own, ought to be based on the characteristics of specialist management workers themselves, and should be formulated as quickly as possible according to the relevant standards of other position series. This is also a necessary condition for science and technology development to have connections outside itself.

4. Coordinate well the science and technology research organizations of higher institutions with science research management organizations.

The original science research management organizations in higher institutions are an office level organizational system--the office of science research. In recent years, there have been two types of science and technology development organizations that have emerged, one being the earlier science and technology service department (science and technology development department), and the other kind is the recent science and technology development company. But the science and technology service department is subordinate to the office of science research, in other words, two names for just one group. We believe that: 1. there is a great deal of science and technology, procedures are complicated, and responsibilities are great. Therefore, structures should not be too small, and for the allotment of personnel there should be guarantees for a certain number of them and their quality. 2. Science and technology development companies and science and technology service departments are best managed together, for if the two are separate it will not be conducive to the overall planning of the school science and technology development, nor for overall arrangements. 3. Science research and science and technology development are two important links tightly forged together in a chain. Their relations must be strengthened, organically integrated, and they must never be severed.

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SUGGESTIONS FOR REFORM OF COLLEGE S&T RESEARCH

Tianjin KEXUEXUE YU JISHU GUANLI [SCIENTOLOGY AND MANAGEMENT OF S&T] in Chinese No 11, 15 Nov 85 pp 32-36

[Article by Shuai Xiangzhi [1596 4161 1807], Office of Science Research, Shandong Shifan University: "Science in the Higher Institutions Is in Urgent Need of Reform"]

[Text] China's economic, science and technology [S&T], and education systems are currently faced with a new trend toward full-scale restructuring, and restructuring of the science and technology systems at higher institutions is also gradually developing. These reforms are of great significance to building China's four modernizations. Reforming scientific research at higher institutions is also an important aspect of this.

I. Reforming Science Research at Higher Institutions Will Suit New Trends in Economic Development

Since the founding of our nation, our higher institutions, and especially those affiliated with major academies, have made important contributions to economic and cultural construction, and some of the research achievements they have made have already been applied in actual production, and, what is more, have gained important economic and social results. However, because they have long been affected by "leftist" influences, the phenomenon in which the science research at higher institutions has been divorced from production has been all too serious. Just looking at the 1984 statistics from two major comprehensive colleges in Shandong alone, we can see that there was no direct relation between 60-70 percent of science research projects and production. Science research at higher institutions, and especially in applications and development research, has not received the attention it should have.

The CPC Central Committee pointed out long ago that "Higher institutions are both centers for education and are centers for science research, and they are am important front army for science research." The "two centers" points mainly to the social function of higher institutions, that is, the position and function of higher institutions in building toward modernization. To see the "two centers" as dealing with only teaching and research in higher institutions would be incomplete.

Currently, if science research at higher institutions is to concentrate on applications and development, then it must take as the goal of its topic selection the promotion of technical advancement, technical transformation, and the renewal and updating of products in industrial and mining enterprises, as well as importing, absorption, and assimilation. By joining higher institutions with factory and mining enterprises, we can make use of the methods of voluntary participation and mutual benefit and multiple formats: 1. to accept commissions from industry and factories through the channels of the technology markets and science and technology trade fairs, sign contracts for specialist projects, help research new products and new techniques, or by representing the development and provision of key equipment; 2. cooperatively undertake technical troubleshooting. Science and technology is a strongpoint of schools, and manufacturing and technique are the strongpoints of factory and mining enterprises. If the two cooperate, they can reduce research times and hasten the transformation of achievements into direct production forces; 3. establish joint research and production groups. With the schools taking on research, design, and experimentation, the factories can do processing and trial production, as well as provide a certain amount of research expenses to the schools. After the achievements have been appraised and are in batch production by the factories, the schools would deduct a percentage from the amount of annual sales (or annual profits). Working this way, we can quicken the research pace of schools, accelerate the transfer of achievements, and increase income; factories can also renew their products, improve their capacity for competition, and greatly increase their profits.

II. Implement a Research Topic Contract Responsibility System, Improve Benefits from Investment

By implementing a research topic contract responsibility system, we would organically combine the benefits for the state, units, and individuals with the responsibility, authority, and benefits of the research group and individuals. This would be beneficial to arousing the enthusiasm of the majority of teachers, would improve work efficiency and investment results, and would be a good method worth trying. But schools are not the same as factories and agricultural and specialist research institutes, so a research topic contract responsibility system cannot be implemented in one fell swoop. We must consider the characteristics of schools and the nature and source of responsibility for research topics, and adopt a corresponding research topic or responsibility contract system.

The most important sources of research topics for higher institutions include: directive planning by the National Science Commission, ministries in the State Council, regional science commissions, and relevant provincial departments, National Science Fund topics, and contractual commissions by factory and mining enterprises. In carrying out topic planning, because topic responsibility is clear for factory commissions, division of labor is specific, and rewards and punishment clear, tasking completion is somewhat better. But projects that are included in the planning of the state and regional science commissions are often not completed on time. Some schools favor seeking out directive research topics for the economic income to the particular unit. They have not given sufficient attention to planning arrangements, selection of personnel, and scientific and technical conditions, and to the necessary guarantees. On the contrary, they concentrate all their resources on those "immediately beneficial" topics that will increase income. The result of all this is that although they can provide new products and new techniques for factory and mining enterprises, as well as allow the researchers themselves to have more economic income, and teachers can obtain more reward money, this all adversely affects the completion of national science research planning. According to statistics, 16 higher institutions in Shandong ought to have completed 25 provincial science commission planning projects, but actually only finished 8, or 32 percent.

Everyone knows that nationally funded science research planning is determined by overall planning of the national economy, and is tasking that is concerned with the whole. If this kind of tasking is not completed, this will lead to national and social losses in technology, and sometimes these losses are extremely serious. Therefore, any unit implementing any kind of responsibility system must first assume national science tasking, and ensure that it is completed on time, with sufficient quality, and in sufficient quantity.

Based on the differing natures and sources of the topics that higher institutions take up, for directive planning an enforced planning responsibility contract system may be implemented; for projects commissioned by factories, a topic contract responsibility system may be used. But no matter what the form of the responsibility system, the responsibilities must be made clear, the times for completion and qualities should be clarified, and the rewards and punishments made clear. When topic tasking has been completed, research units and individuals may both receive a certain economic income.

If directive scientific research topics implement an enforced planning responsibility contract system, it can be done so that the school (office of scientific research) signs enforced planning contract documents with each department or institute. The contents of that contract would include: the research subjects, technical requirements, progress arrangements, personnel participating, required conditions (expenses, materials, instruments and equipment, and experimentation sites), and methods for reward and punishment. After the contracts have been signed, the topic group will formulate particular working plans, will place certain responsibilities on people, and will guarantee the on-time completion of the planned tasks. Based on the contract requirements, the school should allocate funds and materials promptly to the topic group. For that research tasking that is completed on time, and also that has outstanding economic or social benefits, or is at a higher academic standard, the topic group and individuals should be rewarded appropriately in accordance with award clauses. Award funds may be taken from a proportion of the research expenses for that project. For those projects not completed according to plan, and where there is no objective reason, this should be taken as the responsibility of those in the unit in charge and of the topic responsible persons, or a portion of the research expenses should be taken back, and they cannot apply for new projects for a certain time.

For topics that are commissions from factory and mining enterprises and that have been obtained through the channels of technology markets and science and technology trade fairs, responsibility contracts can be signed between the departments or institutes and the topic group or research laboratory. The contents of the contracts can be according to the needs of the factories, but should include clarification of responsibility, the division of labor, and punishments and rewards. We want to be responsible to society, and want to allow the achievements of research to truly produce economic results and to be worth the practical experience. To improve the returns on investment, schools should use project research funds or development funds that have been arranged within the school, or they can also implement bidding for topics and contracts for compensated usage.

III. Expand the Autonomy of Research Institutes and Laboratories

The phenomenon in higher institutions of "too secure, with stifling control" has been quite serious. When research units at higher level institutions have no authority over personnel or financial affairs, and there is a lack of vitality in economic construction, this sort of situation impedes the development of personnel intellect and creative abilities, nor is it a benefit to producing either achievements or talent. The author believes that reform should be undertaken in the following aspects:

1. There should be a certain amount of authority over personnel by research organizations. Research institutes would implement institute director responsibility systems, where institute directors have the authority to decide on facilities for organizations within the institute, and the authority to appoint or dismiss cadre. The deputy director can act in the name of the director, reporting to departments at higher levels for approval of appointments.

Within the research institute there should be freedom of organization for the topic groups, and there should also be gradual implementation of an employment system. The hiring system would chiefly operate within the institute, but based on the needs of the work, the institute could also go outside the institute to hire scientists, technicians, and technical workers, and can as well recruit graduate students and college students to participate in the research. As for those who are unemployed or are being sent away from the institute, there is the authority to make other arrangements and to aid in separation.

2. Research units would have the authority to use funds. We would change the troublesome method of the past in which spending even 1 yuan required signatures from the lab, the department (institute), and school. Use of science research funds can be done with three level control, namely, the school, the department (institute), and the lab or topic group. Anything at 2,000 yuan and below can be approved by responsible persons in the lab or by those responsible in the topic group; 5,000 and below can be approved by department (institute) the respective persons of responsibility; 10,000 and below can be approved by the office of science research (outlays above 10,000 yuan must be submitted to the responsible institute director). Science research development funds earned by the research institute may be arranged in general by the institute director for use primarily in laboratory construction and in arranging projects selected by the institute itself.

3. Science research organizations should have the vitality to cater to economic construction and the needs of society. Under the premise of ensuring completion of assigned science research tasking, we should permit departments (institutes) to integrate the research directions of a unit, fully using their own technical capabilities and conditions. On a contractual basis, commission other units for the tasks of research, experimentation, trial production, and technical processing. Also, on the basis of the compensated transfer of rights to technical achievements, sell small and medium trial products and develop technical servicing for the outside to generate economic income. Specialist research institutes should operate science research production models, both for study and for batch production, to gradually reduce the service fees that are provided by the state.

4. Those responsible for research institutes and laboratories should have the authority for rewards and punishment. Those responsible for research institutes and laboratories should establish a certain awards fund to reward outstanding accomplishments in research and in dissemination of achievements, to reward the greater contributions to economic construction and to society, and to reward scholastic innovations, and greater rewards for the most outstanding. Also, in the aspects of housing and living amenities, these accomplishments should be reported to relevant departments for appropriate consideration. There should be economic punishment for those who do not abide by distribution, and for those who cannot complete research tasking when there is no objective reason.

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PROGRESS REPORT ON CHINA'S NEW PATENT LAWS

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 2 Nov p 3

[Article by Chen Naijin [7115 0035 6651]: "China's Patent Laws Have Stimulated Inventions and Creativity"]

[Text] Beijing, 30 Oct, Xinhua--In the nearly 7 months that China's patent laws were in effect from 1 April of this year through 26 October, the China Patent Office had received 11,609 patent applications of three types: inventions, new types of applications, and designs.

This was reported by Huang Kunyi [7806 0981 4135] at the opening today of the Beijing Conference on Industrial Property Rights. He said that for several months not only has the volume of patent applications been much greater than anticipated, but the structure has worked out well. For example, the proportion of domestic and foreign applications has been maintained at 2 to 1, some 7,660 domestic patent applications having been received as compared with 3,949 foreign patent applications.

This shows that the Chinese patent laws have both been a stimulus to invention and creativity domestically, and have widely gained trust abroad. The proportion of invention patent applications to patent applications for new applications and designs have remained at about 2 to 1. The volume of invention patent applications has already reached 7,085, which shows that the number of patent applications are at a high level of inventiveness and creativity.

Huang Kunyi pointed out that among Chinese domestic patent applications, the proportion of vocational inventive creations to non-vocational inventive creations has largely stayed at 1 to 1, which shows that the Chinese patent laws have both encouraged enthusiasm for invention and creation among socialist enterprises and service units, and have also encouraged enthusiasm in the broad mass of workers to engage in invention and creation outside their work time. Regarding this latter situation, they have not been dependent upon research expenses from the state, but have been able to contribute a great deal of invention and creation to society, which is of benefit to the task of socialist modernization and progress in human civilization.

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GOALS OF NATIONAL S&T SURVEY DISCUSSED

Tianjin JISHU SHICHANG BAO in Chinese 12 Nov 85 p 1-2

[Unattributed article: "Song Jian, Chairman, National Science and Technology Commission Answers Reporters' Questions at National Training and Working Conference for Science and Technology"; first paragraph is source-supplied introduction]

[Text] Editor: The national training and working conference for the science and technology [S&T] survey was held from 5 November through the 14th in Tianjin. Song Jian [1345 0256], Deputy Director of the State Council Science and Technology leading group and chairman of the National Science and Technology Commission, attended the meeting and spoke there. During the period of the meeting, reporters from this newspaper put several questions related to the science and technology survey to Chairman Song Jian.

Question: What is the significance and goal of this survey?

Answer: At its 10th meeting, the State Council Science and Technology leading group decided that during the fall of this year and the spring of next, they would undertake a national science and technology survey, which is an extremely important and very urgent matter. Currently, the sixth 5-Year Plan to develop the national economy is just about to conclude, and the seventh 5-Year Plan is about to begin. At this critical moment, we want to allow restructuring of the science and technology system to develop deeply so as to better cater to economic construction, and to continue adjusting and stimulating scientific and technical capacities toward serving the chief goals of the national construction. We also want to allow them to carry out science and technology development plans in the seventh 5-Year Plan, and so must undertake a science and technology survey throughout the country. After the survey, we will gather the total data reflecting the condition of science and technology at the end of the sixth 5-Year period, as well as structural data, so that later, leadership organizations and research departments at every level can provide quantitative data for macroscopic control and analysis in the aspects of political, planning, and decision making. This will allow all areas of society to understand the whole picture of science and technology to better monitor and support the process of science and technology. In this survey, we will establish a sound system of scientific and technical statistical indexes, will cultivate and train science and technology statistical workers, and provide a unified model and norm for gathering and storing data for base level statistical units. Through stratified handling, we will establish a statistics data bank network to quicken the pace of modernizing the statistics system. The results of this science and technology survey will aid in comparing our science and technology with various countries of the world and to draw from the experiences of developed nations, which will meet the needs of our open door policy and of the development of our science and technology; at the same time, for all levels of science and technology management departments and chief management personnel, it can improve the degree to which management can become scientific and also improve the standard of management.

Question: How are we to understand the importance of scientific and technical statistical work?

Answer: Speaking from the point of view of the whole country, science and technology is a complicated system, and if we use qualitative methods alone to analyze problems, there is already no way to meet the needs of development. If we are to allow the management of science and technology to get onto a scientific track, then we must pay attention to quantitative analysis. This is a developing trend in modern management, and it is information that management personnel must become aware of. In the past, people have always seen statistics as expendable, even to the extent of calling it an "above quota responsibility," which is incorrect. Lenin said, "Social statistics are one of the most powerful weapons for understanding society." Actually, statistics are the most important basis and means for scientific management. As the restructuring develops more deeply, science and technology management organs at all levels are going to be faced with paying close attention to macroscopic conditions, and with the duty of working out accurate policies. This is especially true for leading cadre, who must be freed from activities that excessively interfere with the autonomy of base level units, who must improve the standards of macroscopic management, who must allow the restructuring to be "lively without disorder" by chiefly focusing on the study of problems of a policy and directional nature, and who must support all this with a statistics system that has become better. Otherwise, we cannot formulate accurate policies and good strategies. If we rely only upon particular events to make our decisions, that would be quite twisted, for when making policy on the basis of "examples," sometimes we will suffer, even to the extent of losing time and opportunities.

For a long time now, the management of science and technology in China has lacked basic data that reflects the characteristics of scientific and technical activities, that is systematic, and scientific. What is the basic situation of our independent research and development organizations? After all, what kind of research and development capacity does each profession and enterprise have? How are we to adjust the deployment of scientific and technical capacities according to needs of the restructuring? How much of science research is put into production? Is the distribution of and structures for scientists and technicians rational? Only through scientific and technical statistics can we clarify these questions, and consequently provide a scientific basis by which all levels of management and decision making departments can formulate accurate science and technology policies.

Question: What are the primary objects and principles of this science and technology survey?

Answer: The primary objects of this science and technology survey are the 4,705 independent research and development organizations at the municipal, prefectural, and national levels, as well as some 5,000 medium to large enterprises. The scope and contents of the survey include: the state of independent research and development organizations, as well as the state of science and technology management organizations at the municipal, prefectural, or higher levels; the state of science and technology associations at all levels; the state of the transfer of rights to patents and technical achievements and the import-export technology trade. This survey demands "a clear concept, accurate data, and scientific methods." Seeing that this is the first time that we have set up a scientific and technical statistics system, there is a certain degree of the experimental to this survey, and it is a start by which China's science and technology statistics system will adapt to modern scientific management. This will be a survey of limited goals, limited time, and limited scope, and will use a limited amount of time to gather in a highly effective manner the data that is most urgent for formulating policy.

Question: What are the particular requirements of this science and technology survey?

Answer: Science and technology management departments at all levels, and especially the leading comrades, should be sufficiently respectful of statistical work. They should adopt strong measures to strengthen statistical work and get this work that is fundamental to management onto the right track. This will allow statistics systems to truly become responders and sensors under management control, and let them sensitively reflect true conditions and trends in the science and technology circles. With the aid of the State Statistical Bureau and the ministry commissions under the Central Committee, we will allow the science and technology statistics system to gradually come into line with the national statistics system and to fill in vacancies in China's science and technology system. Beginning right now, the science and technology management organizations at all levels will all offer specialist statistics services to provide to specialist staff statisticians. Scientific and technical statisticians must have strong sense of service, must have a broad scientific knowledge and training, and must strive to use scientific methods and modern statistical means to do this work well. Comrades participating in this training and working conference for the science and technology survey may be said to be the "foundation" of this effort, and are the "seed group" to develop a science and technology statistical system that is both suited to China's national situation and is also up to international standards. We want to develop creativity, and under conditions where time is short and the responsibilities heavy, to finish the science and technology survey, and open up a new aspect to China's science and technology statistics work.

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NATIONAL DEVELOPMENTS

REPORT OF NATIONAL TECHNOLOGY MARKET SURVEY GROUP

Tianjin JISHU SHICHANG BAO in Chinese 5 Nov 85 p 1

[Unattributed article: "A Prosperous Technology Market Waits for Stronger Guidance"; first paragraph is source-supplied introduction]

[Text] Editor: Recently, the "Joint Survey Group for Policies and Rules and Regulations Related to the Technology Markets" sent out by the National Technology Market Coordinating and Guidance Small Group visited in turn the provinces and cities of Hunan, Guangdong, Shanghai, Xiangtan, Zhuzhou, Changsha, Guangzhou, Foshan, and Jiangmen, thoroughly investigating conditions for development in the technology markets and problems that have come up. What we have printed below is an abstract of their survey report.

I.

Since public announcement of the resolution by the CPC Central Committee regarding restructuring of the science and technology system, the commercialization of technical achievements and activities to open up technology markets have been rolling forward like waves in the ocean, and multi-level, multi-channel, and multi-format technology trade activities have been lively as never before.

Of the places visited by the survey group, what we saw first was technology trade and exchange organizations springing up like bamboo shoots after a spring rain, breaking through everywhere. According to incomplete statistics from the surveyed regions, there are more than 850 technology trading and consulting services of various sorts at the provincial level, 104 among which are in Changsha and 316 in Guangzhou, and at Shanghai's Jiaotong University alone there were more than 60 technology service companies. Various joint operations and joint groups, established using the format of technology shareholding, have sprung up as well. There are more than 460 of these in Hunan, more than 300 in Guangdong, and the Huadong Chemical Engineering Academy in Shanghai alone has 8 jointly operated plants and 20 joint groups.

Technology development service organizations from different systems in many places have already formed networks, each a front army with real strength, "each showing its special prowess," and with new prospects for serving the development of production. As for example, what is called the 8th Route Army in a Shanghai technology market: the Shanghai Science and Technology Development and Exchange Center and the Shanghai Industrial Fund, and the Haixing Technology Development Company, the Chinese Academy of Sciences Science and Technology Development Service Company, the Science Association's Consulting Service Center, the higher institutions' Science and Technology Service Center, the staff technology association, and the civilian technology development organizations.

Still other areas have used the strength of overseas Chinese and their families to start technical and economic discussions and trade activities in Hong Kong and outside of China. They have imported foreign funding and technology to solve problems in China regarding technology development and technology renewal. As for example, Foshan, situated in the delta of the Zhujiang, which held discussions in Hong Kong in April of this year regarding the importation of technology and economic cooperation. They signed contracts and letters of intent with overseas Chinese and foreign commercial interests in amounts totaling more than 500 million US dollars. In Hong Kong, the city of Jiangmen held similar discussions and trade fair, at which they imported 106 technologies, for a total of $310 million.

II.

The survey group also saw that after technology markets had been opened, this accelerated the development and prosperity of urban and rural economies, and also brought life and vitality to research groups and colleges and universities. Technology markets have already become bridges and links from science and technology to the economy.

The Changsha Municipal Science and Technology Development Center caters to small to medium enterprises and town and township enterprises, is actively developing technical troubleshooting and technical consulting, and organized four professors to take charge of technique problem solving regarding the nationally famous Liuyang fireworks luminophor aluminum magnesium alloy. In only half a year's time, they made fireworks into the largest producing industry in Liuyang County, with an annual production value of $140 million. The Xiangtan Science and Technology Consulting Service Center with only four workers, organized more than 500 technicians into consulting for more than 153 projects both in and outside of the province, and in doing so saved three factories. They renewed the Zhaotan Chemical Plant from a situation of yearly losses for the 10 years of its existence, where it was about to fold, to a chemical plant with an annual production of 500 tons of barium nitrate, the product of which was in the international market in less than 1 year earning 500,000 yuan a year. The Shanghai higher level institutions Science and Technology Service Center organized the Huadong Chemical Engineering Academy to consult for the Baogang diversion project construction program, and when they changed from diverting water from the Dianshan Hu to getting it from the Changjiang, it saved the state 20 million yuan.

Opening up technology markets has allowed research units and colleges and universities to obtain better economic results. Based on statistics for 45 higher level institutions in Shanghai, in 1982 those schools had an income from technology of 7 million yuan, which in 1983 was 19 million, in 1984 was 30 million, and in the first half of 1985 had reached 36 million, which was from 30 to 40 percent of their operating expenses.

Many research units have used the technology markets to feel out the needs for technology by production units, and have consequently found research topics in the needs of society. The Guangzhou Pharmaceutical Industry Institute did not not make any deals at the National Technology Exchange and Trade Fair, but then later, after understanding the needs of the buyers, some took out technical achievements that had a market and as independent companies held technology trade fairs, making 72 deals with a total trade value of 1.8 million yuan.

What was especially encouraging to people was that the process by which scientific and technical achievements were transformed into actual production forces quickened as the technology markets opened up. The dissemination rate for scientific and technical achievements in Hubei Province improved from the 20 percent of 1980 to 60 percent in 1984. The 49.6 percent in Hunan Province improved to 59.3 percent in 1984. The application rate for scientific and technical achievements in Changsha for 1984 was 85 percent, and 60 percent were appraised for the transfer of the application rights in the same year; research achievements by independent institutes in Guangzhou in 1984 went into production applications at a 76 percent rate, which was an improvement of 6.4 percent over the year before. Before technology markets had formed in Shanghai, the rate for transfer of achievement rights was only 20-30 percent, while among the 1,585 scientific and technical achievements in the 1984 economics commission system, the rights to 834 were transferred to production units, which is 52.6 percent.

III.

The current technology markets may be called a pleasant prospect, but some problems can still be seen, which are concentrated in the fact that policy guidance and macroscopic management cannot keep up with the developing situation.

First of all, a great number of different types of technology development organizations do not have centralized approval, monitored guidance, and management coordination; holding various technology exchange and trade fairs by names of all sorts, while no department can give accurate figures, nor anything about the talk and trade situation, nor technology channeling; this results in the technology markets in some locations giving rise to new fragmentation. Therefore, the survey group recommends that each area focus on the entity and establish corresponding technology market structures for organization, coordination, and management to attract the participation of the departments of science and technology, economics, finance, tax revenue, banking, industrial commerce, judicial, education, and statistics. These unified coordination and management structure's would assume the following responsibilities: formulate policies and rules and regulations for technology markets, enhancing the macroscopic guidance of the technology markets; get information through; coordinate the work; undertake organization related to the technology markets, as for example registration, approval, statistics, and management of techonology trade contracts and arbitration.

Then, there is the problem of distribution of the income from transfer of the rights to technology. Currently, distribution of income from transfer of the rights to technology goes through many doors, the standards for different departments vary, and it is not done according to the nature of service, but rather is divided according to the department system, which creates conflicts within departments and systems. The survey group feels that distribution of the income from transfer of rights to technology should be strictly according to the principle of "division according to the amount of labor." It is recommended that unified methods be worked out that will avoid different departments and systems doing things their own way.

Third, many scientific research units and people who work in the technology markets are very concerned about taxes on transferred rights to technical achievements. We feel that income from the transfer of rights to technology ought to include transfer of rights to achievements, technical consulting services, technical training of talent, as well as any other technical income from assumption of a project other than hardware. These technical incomes would be exempt from taxes in the near term, based on the spirit of the "Resolution by the CPC Central Committee Regarding Restructuring of the Science and Technology System." That is to say that all activities having to do with the production of intellectual commodities and the circulation and exchange of technology should be exempt from taxation; all production and exchange or operation of material commodities ought to be taxed according to statutes (new products are exempt as provided for by relevant national provisions); all individual income will be taxed according to statutes for individual payment of taxes.

In the restructuring of the science and technology system, changing the funds allocation system and opening up the technology markets are two parts to one problem, they exist together, and are cause and effect of each other. Therefore, the survey committee believes that the tax revenue system ought to be appropriately adjusted, and for those research units that are actively undertaking reform, are changing their allocation system, and that do not need service fees, there should be an exemption from or reduction in taxation for encouragement.

In summary, the new problems discussed above await new surveys and study and the joining of each relevant department to propose methods for solution, and to allow continued perfection and development of the technology markets.

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RESULTS OF ONE SICHUAN S&T TRADE FAIR DESCRIBED

Chengdu SICHUAN RIBAO in Chinese 6 Nov 85 p 1

[Text] It appears on the screen of a computer responsible for this province's fall technology achievements trade fair: in 4 days time, the number of transactions for the whole fair has already reached 2,125, and the volume of trade had broken through the 200 million yuan mark.

For 8 days now, the trade fair had been uncommonly active and business was prospering. Sellers were not giving up their efforts, and one after the other come up to give their pitch; buyers were considering long and hard, carefully considering the offerings. There were unexpected projects among the transactions, which yielded results that were pleasant surprises. Staff at the provincial and prefectural mining bureaus discovered strontium bearing reddish black ore of high grade and in large reserves, which, because of a lack of communication went unsold. Chemical engineering plants in Linshui and Pengshan counties had prepared as long ago as 1978 to take up strontianite production, but there were no ore resources. At this trade fair, both sides put their heads together and the difficulties were resolved.

Among projects transacted, some generated foreign currency and others saved on it. Military project plant No 570 had to buy screwtap dies from Hong Kong every year. At this trade fair, they discovered that plant No 7102 of the Ministry of Astronautics could manufacture them and at a price less expensive than imported. Right away, they signed a contract with that plant for 800 sets of screwtap dies. This was both convenient for production and also saved a great deal of foreign exchange.

Leadership of town and township enterprises from the top on down paid very close attention to this trade fair, organizing some 10,000 people to attend. In 4 days time, they had made deals for 263 projects, for a total of 30 million yuan, which was one-eighth of the total amount for transactions.

Trade by Office of Nationalities was also active. Transactions in 8 days totaled 14 million yuan, there were 20 projects for imported technology and one for bringing in talent. They warmly welcomed people from all areas to make plans to develop the nationality regions.

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NATIONAL DEVELOPMENTS

PROVINCIAL SCIENCE COMMISSION SUCCESSES DESCRIBED

Chengdu SICHUAN RIBAO in Chinese 13 Nov 85 p 1

[Article by Tian Majiang [3944 7456 3068]: "Implement an Open Door Policy, Accelerate Science and Technology Development"]

[Text] Our provincial science and technology department actively develops international scholastic exchange, which has achieved outstanding results.

For more than 4 years, the provincial science and technology department has entertained more than 1,400 people who have come from more than 300 companies, enterprises, scientific research units, and as officials from more than 70 nations and regions. In addition, it has signed science and technology exchange and cooperation agreements with more than 20 foreign units. There have been more than 40 occasions where foreign specialists and scholars and leaders from companies and enterprises, invited by the Sichuan Province Science and Technology Exchange Center, have come to Sichuan for various technology exchange conferences, technical discussions, and technical exhibitions. They have developed wide-ranging technical exchanges, have obtained large amounts of foreign scientific and technical information, have imported more than 200 samples of the newest foreign products for our province, and through the borrowing of experiences and trial productions, these things have accelerated the renewal and updating of certain products of our province and the development of new products. After the electronic mosquito eliminator imported by an instrument calibration plant in the Xicheng district of Chengdu was improved, it was better than the foreign model. Then, after resale in more than 10 countries and regions in Asia, Africa, and Europe, annual output value reached 360,000 yuan. In 1981 and 1982, after this province invited some Japanese companies to undertake technology exchange regarding the development of (TIAN YE JU) and refining (TIAN YE JU) glucoside, some departments in the provincial Office of Agriculture and Animal Husbandry in cooperation imported (TIAN YE JU) seeds to develop within the province. The Chengdu Chemical Reagent Plant successively refined (TIAN YE JU) glucoside in complete accordance with standards, the sweetness of which is 250 times that of sugar. The results of this imported technology earned the Sichuan Provincial Prize for Major Scientific and Technical Achievements, and was ranked as a new technology for emphasis in dissemination throughout the province. This kind of (TIAN YE JU) glucoside is already being sold abroad, and is earning foreign exchange for the state. In 1983, since the provincial science commission arranged for biomedical engineering artificial heart valve membrane specialists from this province to go to the United States for a visit, they have gradually mastered the advanced technology to manufacture artificial heart valve membranes. After a year of experimentation, a bovine heart with artificial valve membranes has been developed to international standards, results from clinical use have been excellent, and many units that have depended upon importing the product have placed orders.

The provincial science commission has also brought in some foreign talent in a planned, gradual way, that has been helpful in solving some key technical problems.

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SHANGHAI ECONOMIC METHODS WITH FOREIGN INVESTMENT

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 1 Nov 85 p 3

[Article by Shen Shiwei [3088 0013 0251] and Xia Ruge [1115 0320 7041]: "Shanghai Has Been Methodical in Using Foreign Funding and Importing Technology"]

[Text] Shanghai, 30 Oct, Xinhua--Shanghai Municipality has paid close attention to the management of utilizing foreign investments and importing technology, and has taken the first steps toward finding a fitting management system and methods that suit the new situation of opening to the outside.

Since Shanghai Municipality opened to the outside, it has made full use of its own economic, technical, and foreign trade advantages to actively make use of foreign investment and to import technology. Currently, the total amount of foreign funding that Shanghai Municipality has already attracted exceeds $1 billion, and 135 Chinese-foreign cooperatively funded, cooperatively run and independently foreign funded projects have been approved. There have been more than 800 instances of importation of foreign advanced technology and equipment, nearly 200 of which have gone into production for a new gain in annual output value of nearly 600 million yuan.

To suit this new situation of opening to the outside, and to reduce errors and losses as much as possible, the Shanghai Municipal Government has worked diligently at macroscopic guidance to achieve both an opening to the outside and management thereof. Their methods have been:

To Establish Comprehensive Coordinating Structures and Management Networks for Utilizing Foreign Investment and Importing Technology

There are two deputy mayors in the municipal government with the responsibility for attracting foreign funding and importing technology, respectively; also, with a deputy mayor as head, they have established a technology importation leading group composed of the planning commission, the economic commission, the commission on foreign trade, and the science and technology commission. This group supervises, inspects, coordinates, and arbitrates through a combined working conference. At the same time, a responsibility system is built hierarchically for each importation or cooperative project. From relevant commissions, offices, and bureaus to the factories themselves, responsibilities are established vertically for project chief, project director, and project factory director, such that there are specialists responsible from top to bottom. Laterally, there is a project observation line based on a financial controller and a bank credit officer to serve the bank's functions in management and supervision, and consequently to allow the whole process of importation form a management network with contacts both vertical and horizontal.

To Enhance the Macroscopic Management of Import Projects

To improve importation efficiency, the municipal government has provided that technology importation projects under $2 million and joint-run projects having a total investment under $5 million can be approved by each responsible office. At the same time that it laid out limits of approval authority, the municipal government worked out overall plans for the city to open to the outside, they pointed out technical transformations of older enterprises that should be considered in attracting foreign investment and in the importation of technology, the overall functions to be attended to in using and enhancing central cities, and demanded that each profession aim for the levels of advancement of similar foreign professions, that it import advanced technology in a planned and focussed way, and that it stimulate the technical advancement of the entire profession. The municipal government also organized industrial, foreign trade, and financial departments, and formulated technical transformation programs for 100 professions on the basis of gaps between several hundred major commodities and their foreign equivalents as surveyed and analyzed. They also determined that 22 professions, such as instrumentation, electronics, knitting, weaving machinery, plastics, and metallurgy, would be the focus of technical transformation.

To Make a Good Overall Balance, to Channel Funds into Projects That Are Knowledge Intensive, Technology Intensive, and That Create Foreign Currency Through Export

Through an analysis of trends in foreign funding and in technical development, the municipal government and relevant departments have made 33 categories of projects among the 22 emphasized professions, concerning engineering plastics, electronics technology, precision machinery, household appliances, photographic equipment, food processing, and post-weaving handling, as the principal directions for funding for import and cooperation. Currently, the majority among the 135 projects of cooperation between Shanghai Municipality and foreign commercial interests are knowledge intensive, technology intensive, and generate foreign currency through export.

To Amplify Rules and Regulations Regarding Foreign Economies

Based on the laws and regulations formulated by the state regarding opening to the outside, and to integrate with the actual situation in this city, Shanghai Municipality has in recent years formulated a group of local rules and regulations regarding foreign economies. Each unit making use of foreign funding and importing technology will, when negotiating and signing agreements and contracts, engage the office of accountants and the office of economic rules for foreign nationals as advisors and witnesses, as well as to write up their opinions on the approval documents.

To Maintain the Opening to the Outside, Enhance Management, and Allow the Use of Foreign Funding and Importation of Technology by Shanghai Municipality to Achieve Remarkable Results

Through the importation and absorption of foreign advanced technology, a group of enterprises, such as foodstuffs, knitting, electronics, textile machinery, plastics, and metallurgy, the original equipment of which was obsolete and the technology of which was behind the times, have been refitted with new technology, and the products of certain industries have gotten rid of their "old look" to gain competitive ability in the international market.

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NATIONAL DEVELOPMENTS

SERVING THE LOCAL ECONOMY WITH SCIENCE, TECHNOLOGY

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 10 Nov 85 p 4

[Text] How is the scientific and research of higher level institutions going to serve the promotion of local economies? It is the belief at Qinghua University they they should actively be the "first and second links" in the transmission of advanced, dependable "short, even, fast" technology to medium and small enterprises and town and village enterprises. They have been achieving preliminary results for a year now.

According to a report in GUANGMING RIBAO, what is meant here by "first link" is that, from the point of view of the higher level institutions, based on the needs for technology of the town and village enterprises and during the process of completing the national comprehensive scientific research projects given them by the nation, they will intentionally break down a portion of small scale, specialized, modern, and highly effective technology projects into research topics for "short, even, fast" technologies, and will specifically organize their efforts into promoting research and development; the so called "second link" is to promote "short, even, fast" technical achievements by various methods, to allow them to be applied by small and medium enterprises and town and village enterprises as quickly as possible.

To be a good "first link," at the same time that Qinghua University completes its teaching obligation and national major research topics and basic research, it will methodically organize teachers into practical technology exchange activities of various types and forms. This will provide a basis for determining research topics in "short, even, fast" technologies. Because high rise buildings are getting more common and there has been an increase in demand for high quality heating plates, teachers in the department of mechanics broke down a rare earth and cast iron heating plate technology while studying the overall topic of "metallurgical characteristics" and achieved results after repeated experiments that allowed the working pressure of hot water heating plates to be doubled, which is very suitable for installation in high rise buildings.

Teachers at Qinghua University have also actively developed the function of the "second link," transmitting advanced, dependable new technology as quickly as possible to small and medium enterprises and town and village enterprises. The department of chemical engineering has used computer-aided design to develop a replacement for a key technology in small chemical fertilizer plants--a new type of furnace comb for a synthetic ammonia gassifier, which resolves a technical difficulty in which gassifiers easily created sediment. This achievement has been promoted in several provincial cities in Hebei, Henan, and Hubei, and many small chemical fertilizer factories have used this new device in just a short time. This has caused a 10 percent improvement in single furnace output, a 10 percent reduction in raw materials, and average yearly economic results for a single furnace of over 100,000 yuan.

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NATIONAL DEVELOPMENTS

CAS EXPANDS EXCHANGES

OW281706 Beijing XINHUA in English 1504 GMT 28 Jan 86

[Text] Beijing, 28 Jan (XINHUA) -- Officials of the Chinese Academy of Sciences [CAS] said today they sponsored 6,000 scholarly exchange visits last year, up from 2,700 in 1980.

The academy has established ties with 50 countries and regions and signed 43 cooperative agreements, they said.

Since 1978, aside from sending its scientists to academic meetings abroad, the academy has sent more than 5,300 scientists to some 30 countries for advanced study or cooperative research in such fields as physics, chemistry, microelectronics, information technology, materials science, bio-engineering, lasers, remote-sensing technology and marine engineering.

In addition, CAS sponsored more than 40 international symposiums in China in the past five years on such topics as science policy, mountain meteorology and polymer materials.

Last August, CAS opened two of its 120 institutes to foreigners and 17 other institutes have opened at least one of their laboratories, at which 32 foreign scientists work jointly with their Chinese colleagues on 24 subjects.

At the same time, several institutes have established joint laboratories with foreign organizations for developing new technology and products, the officials said.

In one case, the Shanghai Institute of Cells cooperated in the field of biology with three scientific institutions from the Federal Republic of Germany.

Also,the Shanghai Institute of Medicine and the Kunming Institute of Botany are developing anti-tumor herbal medicine together with a Japanese company. Chinese and British scientists last summer conducted a joint survey of the Ginghai-Tibet plateau.

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CSO: 4010/2007

NATIONAL DEVELOPMENTS

CAS SURVEY SHIP RETURNS FROM WESTERN PACIFIC

OW281953 Beijing XINHUA in English 1917 GMT 28 Jan 86

[Text] Guangzhou, 28 January (XINHUA) -- A scientific survey ship, the "Shiyan 3", of the Chinese Academy of Sciences [CAS] returned here today after completing a 7-week survey mission in the western Pacific.

During its 13,000 km voyage, the ship made observations of the ocean and the atmosphere ranging from 4,000 meters in the water to 16,000 meters above the sea level.

It is determined that the temperature of the water 4,035 meters deep in the western Pacific east of the Philippines and north of Indonesia, is 15 degrees centigrade, and the temperature at an altitude of 16,000 meters is 85 degrees below zero centigrade.

Data on five layers of the sea current were acquired by placing a buoy for 60 hours at an observation station 3,058 meters in the water along the equator.

In an equatorial sea area, a profile on key meterological elements over 1,000 meters above the sea was taken. In the same area, Chinese scientists aboard the ship discovered that there is no connection between the daily change of water vapour and the day length.

They also discovered that there is no obvious daily change in the interactions between the ocean and the atmosphere in a tropical sea area in winter.

The ship came across a force six northwest wind in an area of the equatorial calms, which testifies that the area under survey is an important passage for atmospheric circulation between the south and north hemispheres. Through their 72-hour observation, scientists acquired basic parameters on interactions between the ocean and the boundary layer of the atmosphere.

These achievements have helped the Chinese scientists obtain a better understanding of the interactions between the sea and the atmosphere.

This survey is part of a key research project to study the interactions between the sea and the atmosphere and the yearly weather changes in tropical areas in the western Pacific.

The project is scheduled to last ten years. Winter and summer surveys will be carried out in [word indistinct] every of the first four years.

The next survey will be conducted in October.

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CSO: 4010/2007

ENGINEERING COLLEGES SERVE ECONOMY THROUGH S & T COOPERATION

OW011146 Beijing XINHUA in English 1127 GMT 1 Feb 86

[Text] Beijing, 1 February (XINHUA) -- Almost all China's colleges of engineering have established cooperative contacts with enterprises and businesses in the science and technology fields, and 70 percent to 90 percent of the research results achieved by universities and colleges have been transferred to economic departments.

According to statistics of the state education commission, more than 300 associations for teaching, scientific research and production have been set up by 30 key universities and colleges with enterprises, and these universities have also signed 800 contracts for long-term cooperation and 7,000 ones for short-term cooperation with enterprises.

Of all the technological items these universities transferred to enterprises, more than 150 have brought in annual revenues of one million yuan each, totalling 810 million yuan a year.

The statistics of 85 colleges show that they have helped economic departments train 350,000 people in the past few years.

Professors and associate professors make up 50 percent of the country's total specialists and other senior technical and scientific personnel, and China has 1,000 universities and colleges.

Since May 1982, when Premier Zhao Ziyang suggested establishment of associations for teaching, scientific research and production in universities, scientific and technological cooperation and technical transfer have gradually become the main and the most effective measures for universities and colleges to serve the national economy.

Many institutes of higher learning offer technical aid and training courses to factories and plants where technicians are lacking. In Sichuan Province 15 colleges cooperated with 400 small and medium-sized enterprises, and 300 of them which had suffered losses now make profits.

In academic areas, universities and colleges have become important scientific and technical bases.

The Tianjin Municipal Industrial Department has established a dozen associations with institutes of higher learning; while Shanghai started its cooperation with universities in 1983 by setting up research institutions at universities.

Many universities have entered into long-term cooperative research on sophisticated technology. A development and research center for petroleum and natural gas, and an institution for chemical reaction engineering have bene set up by the Ministry of Petroleum Industry and Nanjing University, and by the China Petrochemical Corporation, Zhejiang University and the Huadong Institute of Chemical Industry, respectively.

To promote technical transfer, many universities and colleges have also set up corporations doing business in technical items at home and abroad. In Shanghai there are 130 such corporations.

Officials from the State Education Commission said that technological cooperation with economic departments helps overcome the defect of separating education, scientific research and economic development that exists in China's educational structure.

For many colleges of engineering, half the funds spent on scientific research come from scientific services to enterprises.

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CSO: 4010/2007

NATIONAL DEVELOPMENTS

PEASANTS ACQUIRE S & T FACTS THROUGH FILMS

OW281832 Beijing XINHUA in English 1646 GMT 28 Jan 86

[Text] Beijing, 28 January (XINHUA) -- It happened one night in Shandong Province. A movie theater in rural Sishui County was showing "The Tricks of Witch Doctors" -- and one was in the audience.

After the documentary was finished and the theater was no longer dark, the old man spoke to the crowd, many of whom had long believed him to be a wizard. This was last year.

"What the film shows is true," he said. "Give up your superstitions and I won't fool you again."

Two thousand km to the southwest, in Sichuan Province, the film attracted another large audience. The village was Hongguang, in Anxian County, where earlier in the year 41 people who could not swim drowned after a local wizard had told them to jump into a pond. Said a local film distributor, "If only the film had been shown earlier..."

In China, where only one out of five people has access to a television set, film remains a central medium of mass communication. And sometimes what the information films convey -- particularly science and educational films -- can change people's lives. Nearly 1,300 copies of "the tricks of witch doctors" have been sold.

Nearly half of China's science and educational films are made by the Beijing Science and Educational Film Studio, which produced 53 last year, the most in its 25-year history.

Zhang Qing, deputy director of the studio, said today the increased production "is in response to the rapid increase in demand."

"The need is particularly urgent in rural areas," she said, "for more and more peasants have come to realize that they can learn from films how to develop agriculture in a scientific way."

"And since many peasants are still illiterate, showing them films can offer a shortcut to teaching them science and technology."

For example, she said, peasants in many districts have learned how to make their drinking water sanitary from the film "Simply-built System of Running Water in the Countryside," and "Pig Raising Technology" has encouraged peasants throughout China to raise pigs with leaner meat.

Other film studios also make science and educational films, including the Beijing-based China agricultural film studio. Among their productions have been films about agricultural and industrial production, enterprise management, education, medicine, science and technology, and health and other practical information useful in everyday life.

Viewers in China's provinces have been promoting the films on their own, particularly in rural areas, Zhang said. In Sichuan Province's Nanchong Prefecture, for example, they have established an association to popularize the films, and in Henan Province's Xinyang Prefecture, they have planned a science and educational film week for the spring.

"These and other examples of viewer support encourage us," said Zhang.

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CSO: 4010/2007

NATIONAL DEVELOPMENTS

NEI MONGGOL BOASTS MAJOR ELECTRONICS INDUSTRY

OW310810 Beijing XINHUA in English 0724 GMT 31 Jan 86

[Text] Hohhot, 31 Jan (XINHUA)--Inner Mongolia Autonomous Region, famed for its grasslands, is now boasting a major electronics industry.

A regional industry official said Inner Mongolia now had 35 electronics businesses making 70 types of products, including radios, tv sets, computers, telecommunications equipment, electronic machinery and domestic appliances.

Output value from this sector last year amounted to 190 million yuan up 100 million yuan over 1984.

Last year, the region produced 175,000 tv sets, 13 times more than in 1980, 504 computer hardware systems, 2.6 times more, and 4,200 electronic surveying instruments, 2.3 times more.

The INNER MONGOLIA DAILY newspaper reported that for every 100 urban families in the region there were at the end of last year 61 black-and-white tv sets, 52 washing machines, 37 cassette recorders, 21 color tvs and 5 electric fans.

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CSO: 4010/1029

NATIONAL DEVELOPMENTS

BRIEFS

LIAONING SCIENTIFIC RESEARCH--During the implementation period of the Sixth 5-Year Plan, Liaoning Province scored a large number of results in scientific and technological research with high technical standards and marked economic returns. The number of these results has reached 9,090 items. Of these items, 3,690 results have very important targets, 7 results have been commended by the national authorities, 56 results have been awarded with prizes of invention, 64 results have been awarded with the prizes of progress, and 1,910 results have been commended by the provincial people's government. In the last 3 years of the 5-year period, more than 3,200 scientific and technological results have been popularized and applied, which create more than 2.23 billion yuan in industrial output value each year and more than 440 million yuan of profits and taxes. [Excerpts] [Shenyang Liaoning Provincial Service in Mandarin 1030 GMT 27 Jan 86 SK] /12232

CSO: 4008/2059

PHYSICAL SCIENCES

INSTABILITY IN LOWER IONOSPHERE AT LOW LATITUDE

Wuhan WUHAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF WUHAN UNIVERSITY (NATURAL SCIENCES EDITION)] in Chinese No 2 [Jun] 84 pp 39-44

[Article by Liu Xuanmou [0491 6693 6180], Liu Cenghou [0491 2582 0624], u Tao [7357 3447] and Cui Rong [1508 2837]

[Text] **Abstract:** In the lower ionosphere, a DC electric field is induced by the collision between charged and neutral particles. In addition, there is a vertical electron density gradient due to the presence of the Hall current induced by the earth magnetic field and the partially ionized plasma in the ionosphere. Under these conditions, their combined effects will cause instabilities in this region. Based on the two-fluid plasma equation, the growth rate γ of these instabilities is derived in this paper. Numerical simulation of this instability shows some fluctuation in electron density in the lower ionosphere 150 seconds after the disturbance. The spatial scale of the undulation is of the order of several hundred meters to several kilometers. In addition, it has a tendency to move in the vertical and horizontal directions. Furthermore, the observation made during the solar eclipse in Yunnan of 16 February 1980 is also discussed.

In the early 1960's, Bowles[1] et al observed that the equatorial electrojet in the lower ionosphere had inhomogeneities of the order of several meters by using incoherent scattering. In order to explain this phenomenon, Farley[2] et al immediately presented the plasma instability theory. Recently, because of the undesirable effect of Spread-F on satellite to ground transmission, Booker[3]-[6] et. al described Spread-F theoretically, as well as experimentally. It is generally believed to be the CR-T instability created in the F region in the equatorial ionosphere. Ossakow[7] and Zallesak[8] conducted a serious of numerical simulations of the CR-T instability in the F region at the equator in the night. The "bubble" theory of the non-linear equatorial Spread-F was introduced. These efforts are limited in the highly ionized F region. The observation made during the solar eclipse in Yunnan on 16 February 1980[9] shows that there are also inhomogeneous bodies of various sizes in the lower ionosphere. We believe that this may be related to the static electric field created due to the disappearance of the ionization source in the lower ionosphere in the band of the solar eclipse. This instability is the result of the combined effect of the Hall current induced by the non-linear polarization EXB, the drift gXB caused by the gravitational field and the electron density gradient in the lower ionosphere. In the lower ionosphere, the collision frequencies between an electron and a neutral particle and an ion and a neutral particle, ν_{en} and ν_{in}, are related to the spin frequencies of electron and ion, Ω_e and Ω_i, as $\frac{\nu_{en}}{\Omega_e} \ll 1$ and $\frac{\nu_{in}}{\Omega_i} \approx 1$ (or >1), respectively, Under these conditions, we derived that the growth rate of the instability, γ is related to factors such as the gravitational force per unit mass g, the recombination coefficient α_R, the collision frequency ν_{in}, the background electron density gradient $(\partial N_0/\partial y)$, and the disturbance wave numbers k_x and k_y.

Theory

The geometrical pattern of the problem under discussion is similar to that used by Ossakow. Instead of the F region, the region involved is the lower ionosphere. The coordinate is chosen as follows: assuming the earth magnetic field is constant and points in the direction of the z-axis (north), the gravity g is in the negative y direction, the x-axis is pointing west, and it is limited to the region near the equator as shown in Figure 1. The continuity and matrix equations describing this two-dimensions (x,y) two-fluid plasma system are:

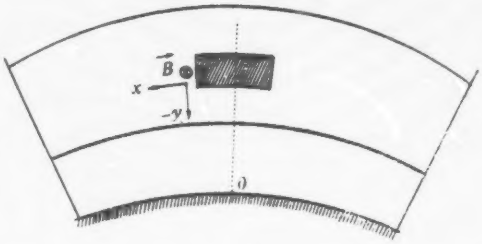

Figure 1. Geometry of the Equatorial Lower Ionosphere

$$\frac{\partial N_\alpha}{\partial t} + \nabla \cdot (N_\alpha \boldsymbol{V}_\alpha) = \alpha_R (N_{\alpha 0}^2 - N_\alpha^2) \qquad (1)$$

$$N_\alpha m_\alpha \frac{\partial \boldsymbol{V}_\alpha}{\partial t} = N_\alpha q_\alpha (\boldsymbol{E} + \boldsymbol{V}_\alpha \times \boldsymbol{B}) + N_\alpha m_\alpha \boldsymbol{g} - N_\alpha m_\alpha \nu_{\alpha n} \boldsymbol{V}_\alpha \qquad (2)$$

Here, the subscript α represents the type of particle (e for electron, i for ion and n for neutral particle). The recombination process in the lower ionosphere is proportional to the square of electron density, which is different from that in the F region. $\alpha_B N_{\alpha 0}^2$ represents an ionization source in the lower ionosphere and $\alpha_B N_\alpha^2$ represents the loss caused by recombination. If we assume that the inertia time (such as the relaxation time of the recombination process in the lower ionosphere caused by a solar eclipse) is larger than the spinning cycle and mean time between collision of charged particles, we can then neglect the inertia term on the left of eq(2). Eq(2) can then be changed to an algebraic equation to solve for V_α. In addition, the electronic and ionic velocities are found to be

$$\boldsymbol{V}_e = \left(\frac{\boldsymbol{E}}{B} + \frac{\boldsymbol{g}}{\Omega_e}\right) \times \hat{B} + \frac{\nu_{en}}{\Omega_e}\left(\frac{\boldsymbol{E}}{B} + \frac{\boldsymbol{g}}{\Omega_e}\right) \qquad (3)$$

$$\boldsymbol{V}_i = P_i \left[\left(\frac{\boldsymbol{E}}{B} + \frac{\boldsymbol{g}}{\Omega_i}\right) \times \hat{B} + Q_i \left(\frac{\boldsymbol{E}}{B} + \frac{\boldsymbol{g}}{\Omega_i}\right)\right] \qquad (4)$$

Here

$$\hat{B} = \boldsymbol{B}/|\boldsymbol{B}| \qquad \Omega_\alpha = eB/m_\alpha$$

$$P_i = \Omega_i^2/(\Omega_i^2 + \nu_{in}^2) \qquad Q_i = \nu_{in}/\Omega_i$$

By using the static approximation $E = -\nabla\phi$ and the quasineutral condition $N_e \approx N_i \approx N$, we get

$$\nabla \cdot \boldsymbol{J} = 0 \qquad (5)$$

$$\boldsymbol{J} = Ne(\boldsymbol{V}_i - \boldsymbol{V}_e) \qquad (6)$$

By substituting eqs (3) and (4) into (6) and calculating Eq(5), we get

$$\frac{\partial\phi}{\partial y}\left(\frac{\partial P}{\partial x} - \frac{\partial R}{\partial y}\right) - \frac{\partial\phi}{\partial x}\left(\frac{\partial P}{\partial y} + \frac{\partial R}{\partial x}\right) - R\nabla^2\phi - g\left(\frac{\partial Q}{\partial x} + \frac{\partial S}{\partial y}\right) = 0 \qquad (7)$$

By plugging the velocity V_{ix} into the continuity equation (1), we have

$$\frac{\partial N}{\partial t} - \frac{P_1}{B}\left[(\nabla\phi\times\hat{B}) + Q_1\nabla\phi - \frac{m_i}{e}(\mathbf{g}\times\hat{B} + Q_1\mathbf{g})\right]\cdot\nabla N = \alpha_{\mathbf{R}}(N_0^2 - N^2) \qquad (8)$$

where

$$P = \frac{Ne}{B}\,\frac{\nu_{in}^2}{(\Omega_i^2 + \nu_{in}^2)} \qquad Q = Ne\,\frac{\Omega_i}{(\Omega_i^2 + \nu_{in}^2)}$$

$$R = \frac{Ne}{B}\,\frac{\Omega_i\nu_{in}}{(\Omega_i^2 + \nu_{in}^2)} \qquad S = Ne\,\frac{\nu_{in}}{(\Omega_i^2 + \nu_{in}^2)}$$

In reality, equation (8) represents the ionization equilibrium equation to be satisfied in the lower ionosphere due to the presence of Hall drift, gravity and cross-sectional gradient. Then, let $\phi = \phi_0 + \phi$, and substitute it into eqs (7) and (8). After linearizing these equations, the condition to be satisfied by the zeroth order potential in the ground state is

$$\nabla\phi_0\times\hat{B} + Q_1\nabla\phi_0 = \frac{m_i}{e}(\mathbf{g}\times\mathbf{B} + Q_1\mathbf{g}) \qquad (9)$$

From equations (3) and (4) we know that this condition makes the ground state satisfy

$$\left.\begin{aligned} &\mathbf{V}_{io} = 0 \\ &\mathbf{V}_{eo} = \left(\frac{1}{\Omega_e} - \frac{1}{\Omega_i}\right)\mathbf{g}\times\mathbf{B} \\ &\mathbf{J}_o = -N_o e\mathbf{g}\times\mathbf{B}/\Omega_i \end{aligned}\right\} \qquad (10)$$

It is obvious that the background velocity of an ion is zero because the mass of an ion m_i is much larger than that of an electron m_e. In addition, electrons move under the influence of the external magnetic field and gravitational field. Hence, J_o is also primarily created by electronic motion. We can see that the ground state is stable. Because P, Q, R and S all contain N, therefore, they can be written as

$$P = P_0(N_0 + N_1),\ Q = Q_0(N_0 + N_1),\ R = R_0(N_0 + N_1),\ S = S_0(N_0 + N_1) \qquad (11)$$

Moreover, the following is satisfied:

$$\frac{m_i}{e}P_0 = \frac{\nu_{in}^2}{\Omega_i^2}Q_0,\ \frac{m_i}{e}R_0 = S_0,\ \nabla\phi_0 = \frac{m_i}{e}\mathbf{g} \qquad (12)$$

Furthermore, P_o, Q_o R_o and S_o remain unchanged with x. If we neglect the effect of higher order potential and other electric fields, the first order equations derived from eq (7) and (8) are

$$\frac{\partial\phi_0}{\partial y}\left[P_0\frac{\partial N_1}{\partial x}-\frac{\partial}{\partial y}(R_0N_1)\right]-\frac{\partial\phi_1}{\partial x}\frac{\partial}{\partial y}(P_0N_0)-\frac{\partial\phi_1}{\partial y}\frac{\partial}{\partial y}(R_0N_0)$$

$$-g\left[Q_0\frac{\partial N_1}{\partial x}+\frac{\partial}{\partial y}(S_0N_1)\right]-R_0N_0\nabla^2\phi_1=0 \qquad (13)$$

$$\frac{\partial N_1}{\partial t}-\frac{P_1}{B}(\nabla\phi_1\times\hat{B}+Q_1\nabla\phi_1)\cdot\nabla N_0=2a_{\mathbf{R}}N_0N_1 \qquad (14)$$

where ϕ_1 is the perturbation potential and $-\nabla\phi_1$ is the perturbation field. Equations (13) and (14) are the basic formulas to find the cross section N(y) on the (xy) plane.

In the lower ionosphere, the densities of electrons and ions are far less than that of neutral particles. Therefore, the collision between charged particles and neutral particles has an important effect on the kinetics. Because limited by such collisions, the drift caused by gravity separates different charged particles somewhat, which induces a DC electric field.

Under the influence of the earth magnetic field, it induces the Hall drift. In general, the tidal motion of the ionosphere is mostly in the east-west direction. The changes of the ionosphere at sunrise and sunset, as well as the perturbation induced by the disappearance of the ionization source in a solar eclipse, can produce a vertical component. The combined effect of these processes can lead to the growth of perturbation, resulting in the characteristic instability in the lower ionosphere. It is most prominent over the equator. In order to determine the growth rate of this instability, we assume that

$$\left.\begin{aligned} N_1 &= N_1e^{j(k_xx+k_yy-\omega t)} \\ \phi_1 &= \phi_1e^{j(k_xx+k_yy-\omega t)} \end{aligned}\right\} \qquad (15)$$

which is substituted into eq (13) and (14). In addition, we assume that N_0、ν_{in}、a_R are functions of the altitude and g、B、Ω_i do not vary with the altitude. After simplification, the angular frequency of the perturbation $\omega=\omega_r+j\gamma$ is a complex number.

$$\omega_r = P_1(k_x - Q_1 k_y)\frac{\partial N_0}{\partial y}\, g\, \frac{-k_x\left[k_y \frac{\partial}{\partial y}(P_1 N_0 \nu_{in}) + k_x \frac{\partial}{\partial y}(P_1 Q_1 N_0 \nu_{in})\right]}{\left[k_y \frac{\partial}{\partial y}(P_1 N_0 \nu_{in}) + k_x \frac{\partial}{\partial y}(P_1 Q_1 N_0 \nu_{in})\right]^2 + (P_1 N_0 \nu_{in} k^2)^2} \tag{16}$$

$$\gamma = P_1^2(k_x - Q_1 k_y)\frac{\partial N_0}{\partial y}\, g\, \frac{N_0 \nu_{in} k_x k^2}{\left[k_y \frac{\partial}{\partial y}(P_1 N_0 \nu_{in}) + k_x \frac{\partial}{\partial y}(P_1 Q_1 N_0 \nu_{in})\right]^2 + (P_1 N_0 \nu_{in} k^2)^2} - 2N_0 \alpha_R \tag{17}$$

Equation (17) is the growth rate of the instability induced by the perturbation in the lower ionosphere. It is clear that the growth rate is positive below the peak ionosphere $\left(\frac{\partial N_0}{\partial y} > 0\right)$, i.e., when the first term is positive and is larger than the second term. However, this condition is difficult to meet in the lower ionosphere. Only on the bottom of the ionosphere or when there is an Es layer then $\left(\frac{\partial N_0}{\partial y}\right)$ is very large. Therefore, this type of instability may only be triggered in the lower ionosphere under the proper perturbation condition. In the upper ionosphere, however, $Q_1 \ll 1$. In this case P_1 approaches 1, and equation (17) becomes

$$\gamma = \frac{k_x^2 k^2 g \nu_{in} N_0 (\partial N_0/\partial y)}{\left[k_y \frac{\partial}{\partial y}(N_0 \nu_{in})\right]^2 + (N_0 \nu_{in} k^2)^2} - 2N_0 \alpha_R \tag{18}$$

With the exception of the recombination term, the result of this equation is the same as that given in reference [7]. This is the expression for the commonly discussed CR-T instability. In addition, we can see from equation (17) that the growth rate is very large when the perturbation is purely horizontal (ky=0). A perturbation purely in the vertical direction (k_x=0) cannot trigger this type of instability. On the other hand, when $Q_1 \gg 1$, it seems that this type of instability might be triggered in the "valley" region of the ionosphere where $\frac{\partial N_0}{\partial y} < 0$ if $Q_1 k_y > k_x = 0$ can be satisfied such as the case of strong vertical disturbance at sunrise and sunset.

Numerical Calculation and Discussion

The objective of this calculation is to determine changes of the electron density cross section in the lower ionosphere when disturbance exists. The starting point is equations (13) and (14), together with the corresponding boundary conditions. It is apparent that equation (13) is an elliptical equation and (14) is a hyperbolic equation. We used a combination of leap-frog and iteration to simultaneously solve this set of partial differential equations. The calculation was carried in two dimensions (x,y). In the process, we kept the terms proportional to ν_{in}/Ω_i in equation (13) and neglected terms proportional to $1/\nu_{in}$. The range of simulation was 8 kilometers in the x direction (42 points at 200 meters apart) and 70 $\sim$ 120 kw in the y direction (52 points at 1 km apart). The boundary condition of N_1 and ϕ_1 is periodic in the x direction. It belongs to the second category boundary condition in the y direction ($\partial N_i / \partial_y = 0$, $\partial \phi_1 / \partial_y = 0$). The initial disturbance is the same as the disturbance B used by Zalesak, i.e.

$$w = \frac{N(x,y,0)}{N_0(y)} = 1 - e^{-z} \cos\left(\frac{\pi x}{20 \Delta x}\right) \tag{19}$$

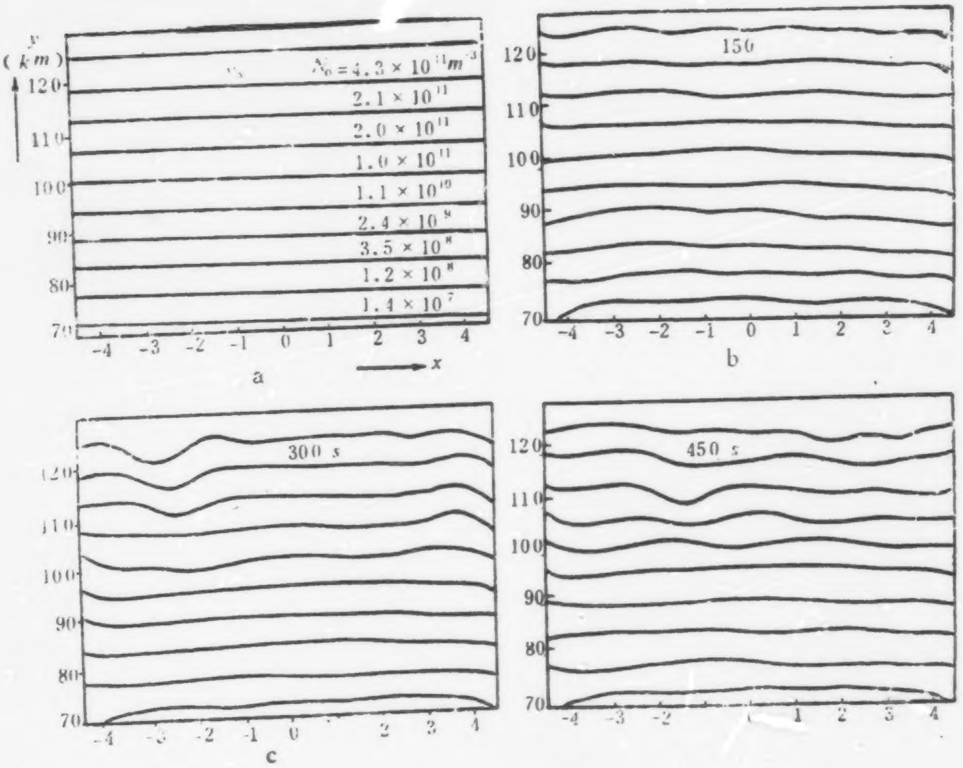

Figure 2. Iso-density Curves Obtained by Calculating N/N_0 at t=0 sec (a), 150 sec (b), 300 sec (c) and 450 sec (d)

Results of our calculation show that in most cases the value of N/N_0 is not different from 1 by much. Figure 2 shows several calculated iso-electron density $N(y)/N(y_0)$ contours at different instances. We can see that initially (0 sec) the ionosphere is divided into uniform horizontal layers. The cross-section does not vary by much at 50 seconds after the disturbance. At 150 and 300 seconds, the cross-section apparently is no longer divided into uniform horizontal layers. In addition, the disturbance has a tendency to move in both vertical and horizontal directions. The scale of the disturbance is of the order of several hundred meters to several kilometers. We are unable to plot the result at 450 seconds because the data did not converge. Furthermore, the Ω_i chosen is on the high side which requires further calculation. Figure 3 shows the variation of the amplitude and its Doppler frequency shift of a high frequency signal (f=5.25 MHz) transmitted by the ionosphere during the solar eclipse in Yunnan on 16 February 1980. The figure shows that the scattered component of the high frequency signal increased significantly after the initial eclipse. Moreover, the Doppler record also indicates that the reflection surface had serious undulations. This shows that non-uniform ionization density bodies in various scales might be excited in the lower ionosphere because of the instability mentioned above. In this case, the ionization source disappeared and the electron density was reduced to create a horizontal static electric field. Charged particles in the high density region outside the eclipse band move toward the eclipse band to create horizontal disturbances. At this time, the Hall drift caused by the non-linear polarization ExB is in the vertical direction. Furthermore, at approximately 17:00 hours local time the apex angle of the sun increased rapidly. The cooling of the lower ionosphere also led to disturbances in the vertical direction. These disturbances might lead to the growth of such instabilities.

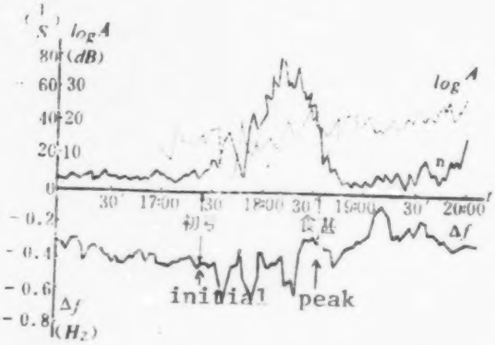

Figure 3. Variation of Amplitude Log A, Decay Rate n and Doppler Frequency Shift Δf of a High Frequency Signal Reflected by the Ionosphere With Time During the Solar Eclipse on 16 February 1980 in Yunnan

(Acknowledgement: The authors wish to express their gratitude to comrades Liang Baixian [2733 4102 0341], Wang Shen [3769 8590], Zhang Xunxie [1728 6064 2750] and Wang Jingfang [3769 2417 5364] for their concern and assistance, to Comrade Huang Tianxi [7806 1131 6932] of Wuhan Physics Institute of the Chinese Academy of Sciences for his valuable suggestions, and especially to Associate Professor Xiao Zuo [5135 1563] of Beijing University for the enthusiastic support and guidance.)

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12553/8309
CSO: 4008/1048

PHYSICAL SCIENCES

CRYOGENICS OF CHINA'S NIOBIUM MATERIAL (Nb2-1)

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 119-120

[Article by Wang Jiasu [3769 1367 4790] and Wang Suyu [3769 4790 3768], Hefei Research Institute of Cryogenics and Electronics Technology: "Superconducting Microwave Surface Resistance of Nb2-1 Material at Liquid Helium Temperature"]

[Text] Text of English Abstract: The experimental research of the superconducting microwave surface resistance with China's niobium material (Nb2-1) at the liquid helium temperature is described. The measurement is made on X-band TE_{011} mode cavity. Unloaded Q_0 value of $4.3\text{x}10^{o}$ is achieved at a temperature of 4.2K. The equivalent residual surface resistance is $1.8\text{x}10^{-4}\Omega$.

In superconducting material at very low frequencies, the superfluid current is dominant while the resistance effect is very tiny. Yet surface resistance exists in superconducting material in the microwave frequency band. The superconducting microwave surface resistance measured on X wave band highly pure niobium at a temperature of 1.3K was $1.5\text{x}10^{-9}$ [1]. The High Energy Physics Institute of the Chinese Academy of Sciences measured the superconducting microwave surface resistance of X wave band highly pure (99.98 percent) niobium at 1.87K as $7.8\text{x}10^{-6}\Omega$. This paper gives the results of experimental research on a superconducting microwave resonator made of Chinese manufactured industrially pure cast niobium ingot (Nb2-1, 99.7 percent pure) and at 4.2K and 9984MHz the superconducting microwave surface resistance was measured at $1.8\text{x}10^{-4}\Omega$.

Superconducting Microwave Resonator System

To measure microwave surface resistance accurately, it is necessary to manufacture meticulously a microwave resonator. The inner diameter and length of the resonator used in the experiments were the same, both 40mm! Two small holes, 4mm in diameter were punched in the resonator's cover plate for input-output coupling of the microwave signal. A hole 3mm in diameter was punched in the center of the bottom plate as a channel for creating a vacuum. After mechanical polishing, the resonator was polished chemically in a triacidic (HF, HNO_3 and H_2SO_4) solution[2] but before polishing the three components, they were first heated appropriately. The function of the H_2SO_4 in the triacidic solution was to slow down the rate of the corrosion of the niobium; the aim of appropriate heating was to obtain a bright level surface, but only when the triacidic mix, heating and corrosion time were optimal could satisfactory results be achieved. In particular, the time should be strictly controlled to obtain ultimately an unusually bright level niobium surface so that the fineness comes close to ∇ 12. The niobium ingot need not be cooled in a high-vacuum. After mechanical polishing it was discovered that the grain dimension was approximately 0.6cm. After chemical polished it was immediately washed in ionized water, then cleaned with analytically pure acetic acid. A superconducting niobium resonator processed in this way can realize excellent superconductivity at the temperature of liquid helium. Bright level superconducting material can obtain good electrical performance, but it is necessary for the surface to be clean for it to be able to maintain its superconducting performance. This experiment paid special attention to this problem. After treating the cleaned niobium resonator with acetic acid, it was immediately placed in a stainless steel vacuum cover, the input and output waveguide sealed windows on the upper cover were sealed with microwave ceramic plates and indium wire,[3] and the oxygen-free copper suction tube on the bottom was directly mounted on the oil-less ultrahigh vacuum pumps. First an ultrahigh vacuum was created then it was heated to about 100°C and the vacuum increased until it reached $1.5x10^{-7}$mmHg then it was pinched using high vacuum clamp, so we could make the waveguide microwave resonator used for testing.

The input/output waveguides were made of stainless steel waveguides with walls 0.2mm thick, to ensure constant temperature and thermal separation from the liquid helium temperature area, the inner walls were coated with copper to reduce waveguide loss. The waveguides on the top of the liquid helium Dewar vessel flange also had sealed windows of ceramic plate and indium wire as described above. The entire waveguide sealed area was taken to a vacuum of nearly 10^{-2}mmHg, then sealed.

Measurement Results and Discussion

The no-load quality factor Q_o of the resonator was in inverse proportion to the residual surface resistance R_s inside the resonator. The geometrical factors of the TE_{001} superconducting microwave resonator used in this experiment were G=780, Q_o=780/R_s. Customarily we used the decay method to measure its Q value.[4] At the temperature of liquid helium, the time it took to drop from the maximum power point to the 3dB was 10μs. Time was measured using a pulse osciliioscope, the wave detector was placed in a completely square-law wave detection state, and at the same time measured the standing-wave coefficient ρ, as 1.54, therefore, Q_L=$0.91x10^6$ and Q_o=$4.3x10^6$, and the corresponding R_{xs} was $1.8x10^{-4}\Omega$. Document [5] showed that at 10GHz on the basis of the theoretical computations given in document [6], at 4.2K, the microwave surface resistance of superconducting niobium at 10GHz R_s=$4x10^{-6}\Omega$. Document [7] at 9.5GHz on the basis of the theoretical computations given in document [8], at 4.2K, R_s=$2x10^{-5}\Omega$. Document [9] measured highly pure niobium which had been smelted four-fold by electron beams and at 4.2K and 9.2GHz, R_s=$3.1x10^{-5}\Omega$, almost the same as the theoretical value of the method described above in document [8]. Although the new chemical polishing technology[2] used in this paper obtained a rather satisfactory niobium surface, due to the limitations of the low purity of the niobium and other conditions, the vacuum inside the resonator could not reach 10^{-9}mmHg, which to a certain degree restricted the reduction of Rs.

A great deal of theoretical and experimental research shows that when the frequency or temperature becomes lower, the surface resistance Rs can become even lower.

Experiments prove that the superconducting microwave surface resistance of domestically manufactured industrially pure Nb2-1 material at 4.2K and X wave band is less than $1.8\times10^{-4}\Omega$, its superconducting resonator's Q value reaches 10^6, and thus it can be used in such passive superconducting microwave circuits as superconducting filters, transmission lines and antennas.

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APPLIED SCIENCES

CONFOCAL LASER RESONATOR CHARACTERISTICS ANALYZED

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 5, No 11, Nov 85 pp 992-996

[Article by Jin Devun [6855 1795 6663], Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences: "A Confocal Laser Resonator"]

[Text] Text of English Abstract: The dynamic oscillation characteristics of a special confocal resonator with $G_1=0$ and $G_2=0$ have been analyzed. This resonator shows oscillation characteristics of a Gaussian standing-wave resonator, a critical resonator, and a travelling-wave resonator, respectively, when the direction of the rectilinear-motion equation for the resonator is changed. The method for designing the resonator is proposed. Experimental results are in agreement with theoretical analysis.

I.

Document [1] analyzes in detail the oscillation characteristics of a laser resonator from a theoretical standpoint, and discusses the differences and connections of Gaussian standing-wave resonator, critical resonator and travelling wave resonator. For a laser with a lens type medium, the characterization of the back and forth matrix A of the oscillation characteristics is[1]:

$$\text{A back and forth} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} = \begin{pmatrix} 4G_1G_2-2A_0G_2-1 & 2B_0G_2 \\ \frac{2A_0}{B_0}\left(2G_1G_2-A_0G_2-\frac{G_1}{A_0}\right) & 2A_0G_2-1 \end{pmatrix}, \tag{1}$$

in which $G_1=A_0-B_0/R_1,\ G_2=D_0-B_0/R_2,\ A_0=1-b/f_T,\ B_0=a+b-ab/f_T,\ D_0=1-a/f_T$. R_1 and R_2 are the curvature radii of the output resonator lens and the rear reflecting lens respectively. a and b are the distances between the front and read chamber lenses and the "basic surface" of the activation medium. f_T is the activation medium thermal focal distance under a definite pumping power. Since the confocal condition $C=0$ we can obtain the confocal laser resonator equation:

$$2G_1G_2-A_oG_2-G_1/A_o=0_o \tag{2}$$

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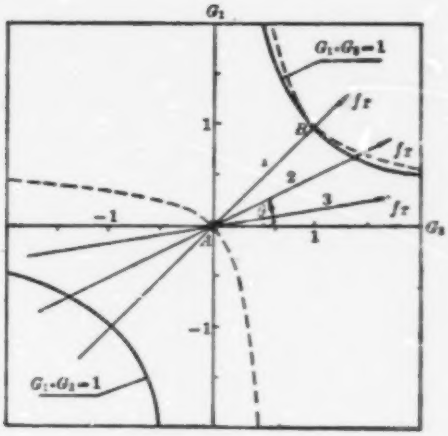
Figure 1 gives the curves of two confocal resonators $A_g=1$, illustrated by the broken lines in the figure. From the results presented in the figure it can be seen that on the confocal curve group there are two characteristic points: A and B. B represents a critical confocal type resonator and since its diffraction loss is great, in actual applications it has a very highly localized nature. However, the confocal resonator represented by A is at a "convergent point" of a Gaussian standing-wave resonator, critical resonator, and travelling wave resonator, thus it has "exotic" characteristics. Since this resonator has relatively low diffraction loss, in the low gain system of a high recurrence rate or continuous solid state laser, this resonator structure is more often adopted. This paper is based on this point and from a theoretical perspective analyzes its dynamic oscillation characteristics, discusses how resonator parameters can be rationally selected, and finally, obtains rather satisfactory results experimentally.

Figure 1.

Dynamic stability diagram of confocal laser resonators



II.

Laser resonator oscillation features are characterized by the characteristic wave surface curve radius R_c[1]:

$$R_c = B/\sqrt{g^2-1}, \tag{3}$$

in which $g=(A+D)/2$. Changes in the resonator structure caused by irregular disturbance of the activation medium thermal focal length f_T are reflected in the dynamic stability diagram as a straight line motion equation[2]:

$$G_2 = \eta G_1 + B_2, \tag{4}$$

in which $\eta = a(1-b/R_2)/b(1-a/R_1)$, $B_2 = 1-(a+b)/R_2 - \eta(1-(a+b)/R_1)$。 η、B_2 are the slope and the intercept. Taking the angle of this straight line and the axis G_2 as θ, as illustrated in Figure 1, it is not difficult to obtain:

$$\theta = \mathrm{ctg}^{-1}\eta。 \tag{5}$$

Clearly, for the confocal resonator $G_1=G_2=0$, $B_2=0$. The corresponding characteristic wave surface curvature $R_{c,cof}$ is

$$R_{c,cof}=\begin{cases} iB_0\sqrt{\eta} & 0<\theta<\pi/2,\ \pi<\theta<3\pi/2, \\ B_0\sqrt{|\eta|} & \pi/2<\theta<\pi,\ 3\pi/2<\theta<2\pi, \end{cases} \tag{6}$$

in which $i=\sqrt{-1}$. The results of Eq. (6) show: when $0<\theta<\Pi/2$ or $\Pi<\theta<3\Pi/2$, $R_{c,cof}$ is a complex number, therefore for a Gaussian standing-wave resonator, the corresponding fundamental mode beam scattering angle $\alpha_{1,cof}$ is[1]

$$\alpha_{1,cof}=K/(B_0\sqrt{\eta})^{1/2}, \tag{7}$$

in which $K=\sqrt{\lambda/\pi}$, λ is the laser wave length. When $\Pi/2<\theta<\Pi$ or $3\Pi/2<\theta<2\Pi$, $R_{c,cof}$ is a real number, therefore for the travelling wave resonator, the corresponding spherical surface wave curvature radius R_{cof} is [1]

$$R_{cof}=\left(\frac{1}{R_1}+\frac{1}{B_0\sqrt{|\eta|}}\right)^{-1}. \tag{8}$$

Clearly, when $\theta=0$ or Π, it is a confocal critical resonator. The results of Eqs. (7)-(8) show: for a confocal laser resonator in which G_1 and G_2 are always zero, not only benzheng [2609 1767] oscillation mode (Gaussian or point beam), but moreover the orientation of the output characteristics (beam scattering angle or spherical wave curve) is very closely related to the rectilinear-motion equation (4) on the dynamic stability diagram. In other words, the orientation of the rectilinear-motion equation (4) is different and the confocal resonator has the oscillation characteristics of Gaussian standing-wave resonator, critical resonator, and travelling-wave resonator, respectively.

For the confocal Gaussian standing-wave resonator, the fundamental wave beam scattering angle $\alpha_{1,cof}$ is in inverse proportion to $\eta^{1/4}$, $B_0^{1/2}$. Thus, the smaller the value of θ, the longer f_T (corresponding B_0 value is large), and the brightness of the corresponding output laser is high. Yet, the radius R_{cof} of the output spherical wave curvature of the confocal travelling-wave resonator is not only determined by the size of the f_T and θ, but also is related to the radius R_1 of the curvature of the output resonator lens.

III.

The confocal resonator structure parameters a, b, R_1, and R_2 with the activation medium thermal focal distance f_T satisfy the equation

$$\frac{a(1-b/R_2)}{1-(a+b)/R_2}=\frac{b(1-a/R_1)}{1-(a+b)/R_1}=f_T.$$

In the actual process of operating the laser, it is frequently difficult to avoid random disturbance of the medium's thermal focal distance f_T. For a confocal resonator of a definite structure, disturbance of f_T leads to the distortion of the confocal resonator into a non-confocal. Taking $m=G_1\cdot G_2$, and using m as a parameter, the changes in the radius R_c of the corresponding characteristic spherical wave curvature according to Eq. (4) is

$$R_c = R_{c,cof}/(|m-1|)^{1/2}, \tag{9}$$

Change of m with f_T is

$$m = \eta[1-(a+b)/R_1 - b(1-a/R_1)/f_T]^2. \tag{10}$$

Clearly, Eqs. (9) and (10) reflect quantitatively the dynamic oscillation characteristics of the confocal resonator. Figures 2 and 3 give the curve of dynamic changes of the characteristic wave curvature R_c-G_1 with the equivalent G factor G_1-f_T. The results show that when the activation medium's thermal focal distance f_T is deflected from the f_{To} value corresponding to the confocal resonator, the changes in R_c causes by increasing changes in the direction of f_T the changes in f_T along the contraction direction are much smaller. Next, for confocal Gaussian standing-wave resonators with a resonator structure having a large θ value, the thermal stability of corresponding R_c with changes in f_T is pretty good (see Figure 2). These useful conclusions are very important for rational design of confocal resonators.

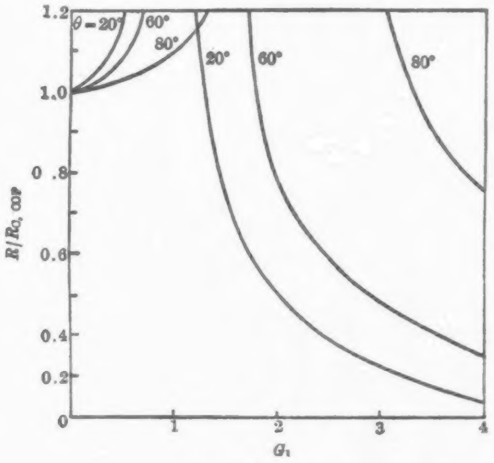


Figure 2. Characteristic wave-front curvature
R_c vs. θ

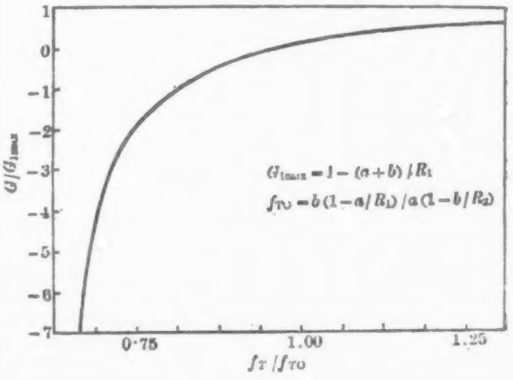


Figure 3. Equivalent factor G_1 vs. length f_T

IV.

Summarizing the above, oscillation characteristics of confocal resonators have an intimate relationship with its orientation of the rectilinear-motion equation (4) in the dynamic stability diagram. After selecting an activation medium and determining the medium's thermal focal length f_T corresponding to a definite pumping power, on the basis of the different demands of actual use for laser output, we can rationally select the resonator parameters:

1. Corresponding to different applications goals and the size of the gain of the activation medium used, the Gaussian standing-wave resonator or travelling-wave resonator should be used. For most low gain systems, the confocal Gaussian standing-wave resonator is appropriate.

2. On the basis of the type of resonator used and the results of Eq. (6), the value of θ should be selected appropriately and at the same time, because of the demands of actual application on the output beam scattering angle $\alpha_{1,cof}$ (or spherical wave curvature radius R_{cof}), selected an appropriate value for $R_{c,cof}$, and make the values of θ and $R_{c,cof}$ design parameters.

3. Solve the following non-linear equation group, and obtain the confocal resonator structural parameters a, b, R_1 and R_2:

$$\begin{cases} 1-\dfrac{a+b}{R_1}-\dfrac{b(1-a/R_1)}{f_T}=0, \\ 1-\dfrac{a+b}{R_2}-\dfrac{a(1-b/R_2)}{f_T}=0, \\ a\left(1-\dfrac{b}{R_2}\right)-\eta b\left(1-\dfrac{a}{R_1}\right)=0, \\ \sqrt{\eta}\left(a+b-\dfrac{ab}{f_T}\right)-R_{c,cof}=0, \end{cases}$$

in which $\eta=\mathrm{ctg}\theta$.

4. On the basis of design results, compute quantitatively the output chacteristics of the confocal resonator:

fundamental mode scattering angle: $\alpha_{1,cof}=K\cdot(\mathrm{tg}\theta)^{1/4}\cdot B_o^{-1/2}$

(for Gaussian standing-wave resonators)

spherical wave curvature radius: $R_{cof}=\dfrac{B_o R_1(:\eta:)^{1/2}}{R_1+B_o(:\eta:)^{1/2}}$

(for travelling-wave resonators)

5. On the basis of Eqs (9) and (10), analyze quantitatively the dynamic output characteristics of the confocal resonator.

If the output beam scattering angle $\alpha_{1,cof}$ or spherical wave curvature radius R_{cof} of the laser resonator designed cannot satisfy the actual application demands, the θ and $R_{c,cof}$ values can be appropriately revised until a satisfactory confocal resonator has been designed.

V.

Using a low gain continuous YAG laser as an example, we carried out experimental researches on the oscillation characteristics of a confocal type Gaussian standing-wave resonator. The dimensions of the YAG rod were ϕ5mm x 105mm, $R_1=\infty$, R_2 was a flat or concave lens. Output resonator lens transparency was 11 percent. The collecting resonator was an single elliptical cylindrical LK-8x75 krypton light pump resonator with an effective length of 100mm. Output power was measured with a JGK-3 laser power meter. The multi-mode laser scattering angles were obtained by direct measurement.

During the experiments, confocal resonators of three different structures were used. The resonator structural parameters, the theoretical computational values, and the results of experimental measurements are given in Table 1. The results show that comparing #3 resonator to #1 resonator, the θ value is 4.5-fold smaller, laser beam scattering dropped by 2.4-fold, and brightness correspondingly increased by 6.3-fold. Comparing #2 resonator with #1 resonator, the θ value is smaller by 1/3, and brightness increased by 1.7-fold. Viewed from the angle of observation results of output stability experiments, #1 resonator output is more stable, #2 resonator is next, and #3 is the poorest. In addition, measurements of multi-mode beam scattering angle α_1 were pretty close to theoretical computed values. From this it can be seen that the conclusions reached in the theoretical analysis of confocal resonators given in this paper are basically correct. These conclusions have definite guiding significance for application of confocal resonator technology.

Table 1. Structures and Experimental Results and Confocal Resonators

Order		1	2	3
Resonator parameters	a(cm)	30	39	65
	b(cm)	30	30	26
	R_1(cm)	∞	∞	∞
	R_2(cm)	∞	-100	-20
Thermal focal distance f_T(cm)		30	30	30
Orientation	θ(°)	45.0	30.6	9.9
	B_2	0	0	0
Beam scattering angle α_1(m rad)		5.89	4.53	2.72
Measured values	output power (W)	12.01	9.20	7.13
	beam scattering angle(m rad)	5.41	4.10	2.21
	brightness $\frac{10^6 (W)}{cm^2 \cdot stero.\ rad.}$	1.039	1.811	6.574

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APPLIED SCIENCES

CHINESE ACADEMY OF SCIENCES STUDIES DH LASER

Beijing TONGXIN XUEBAO [JOURNAL OF CHINA INSTITUTE OF COMMUNICATIONS] in Chinese Vol 6 No 1, Jan 85 pp 65-70

[Article by Wang Qiming [3769 0796 2494] of the Institute of Semiconductors, Chinese Academy of Sciences: "An Investigation of Co-Cavity Two-Section (CCTS) DH Lasers"]

[Text] Abstract: This paper reports an investigation of CCTS AlGaAs/GaAs, InGaAsP/InP DH lasers. It is shown that CCTS DH lasers have multiaction characteristics both in steady states and in transient states. As a three terminal device, the lasing state may be controlled by selecting the operating mode such as "on" or "off" and by controlling the pulse sequence. It is interesting that bistable behavior in the output can be obtained in these lasers under appropriate experimental conditions.

Introduction

The rapid development of large capacity long distance single mode fiber optical communication has posed new challenges on the carrier light sources--semiconductor lasers. They must not only have a million hours of service life to insure the reliability of the communication system but also have stable dynamic single frequency output and as many controllable features as possible. Semiconductor lasers with distributed feedback (DFB) and distributed reflectors (DBR) based on the Bragg diffraction effect of the semiconductor grating were once thought to be promising multifunction single frequency lasers; however, since the technology for grating fabrication is difficult and the yield of component production is low, efforts in recent years have been directed to the development of composite cavity lasers. The co-cavity lasers still used the conventional Fabry-Perot resonance but two or more lasers are coupled on the same chip with a waveguide. Examples are the twin cavity guide coupled (TCGC) laser, the co-cavity twin stimulation (CCTS) laser and the recently proposed cleavage coupled cavity (C^3) laser. Such composite cavity lasers have two or more source zones of different states of stimulation and the single frequency laser output is achieved through the Q-switching or mode-locking effects due to the coupling of laser lights emitted from the different zones. Such lasers may also possess three terminal or multiterminal features such as frequency tuning, picosecond pulse generation, and bistable output. Such new features will not only satisfy the multitude of requirements in optical communication but may also advance the research of high speed signal processing and optical computers.

In this paper we present some preliminary but important results in our study of the AlGaAs/GaAs, InGaAsP/InP CCTS DH composite cavity lasers.

I. CCTS DH Lasers

Figures 1 and 2 show the AlGaAs/GaAs, InGaAsP/InP CCTS DH lasers we have developed. The chips are five-layer structures grown with the conventional LEP technique. The parameters of these lasers can be found in Refs. (1) and (2). The laser in Figure 1 has a cavity length of 555 µm, a strip width of 15 µm, the source region has a thickness of $d = 0.5 - 1.0$ µm and the high resistance isolation is fabricated with a proton bombardment technique. The electrode isolation troughs are photoetched before the chip is divided into laser tube chips. The trough width is 5 µm and the trough is made with a selective etching method. The trough bottom is located as close to the top of the source zone as possible to avoid charge leakage in the lateral direction. The isolation resistor should have several thousand ohms if possible so that the laser is divided by the trough into two electrically isolated and optically connected zones: LD_1 and LD_2. The two zones can be supplied independently with power and by adjusting the voltage injected into the two zones, the output characteristics of the laser may be controlled, making it effectively a three-port device. Devices of this structure can only be coupled positively and the heat dissipation is poor. The device with a strip width of 15 µm should only be operated in the pulse mode at room temperature because the threshold current is relatively high.

Figure 2 shows a InGaAsP/InP CCTS laser that we developed. It also has a proton bombarded strip structure and, before forming into tube chips, high resistance zones of various dimensions are formed by proton bombardment in a direction perpendicular to the strips. The laser cavity is 200-300 µm long and the width of the high resistance zone is $b' = 15-30$ µm. It is really a special case of the device shown in Figure 1 because LD_2 maintains an injection current $I_2 = 0$. Since this device can be reverse coupled and the heat dissipation is good, it can be operated in the CW mode at ambient temperature.

II. Improved CCTS and Control of the Output Characteristics

Using LD_2 as the control port to select a constant injection current I_2 and using LD_1 as the working port to continuously vary the injection current I_1, one can obtain a set of output characteristics curves $L-I_2-I_1$. Figure 3 shows the experimental output curve of the 25 AlGaAs/GaAs CCTS operated in a pulsed mode under ambient temperature. As can be seen, no kinks are observed in the experimental output power range of the laser, the laser may be regarded as operating in the single wire stable mode. The threshold current of the laser is I_{tho} and the corresponding current density is J_{thoo}. The solid lines are a set of output curves obtained in separate feeding and using I_2 as the reference current. As shown in the figure, when $J_2 < J_{tho}$ or $I_2 < I_{tho}$, the working threshold current I_{th1} increases rapidly as I_2 decreases and the external differential quantum efficiency η drops substantially. Conversely, when $I_2 > I_{tho}$ or $J_2 > J_{tho}$, I_{tho} also decreases when I_2 increases, but the external differential quantum efficiency η remains a constant. The "on" and "off" of the CCTS laser can therefore be controlled by adjusting I_2 and the internal modulation of the output light of the CCTS laser can also be achieved through I_2 injection.

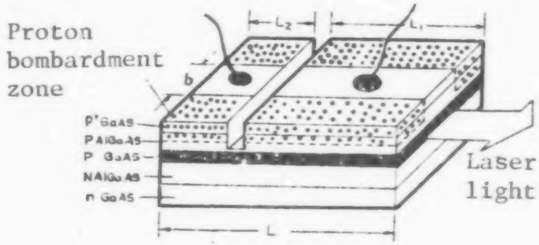
Proton
bombardment
zone
L_2
L_1
b
P^+GaAS
P AlGaAS
P GaAS
N AlGaAS
n GaAS
Laser
light
L

Figure 1. Schematic Diagram of the Structure of a Trough Isolated AlGaAs/GaAs CCTS DH Laser

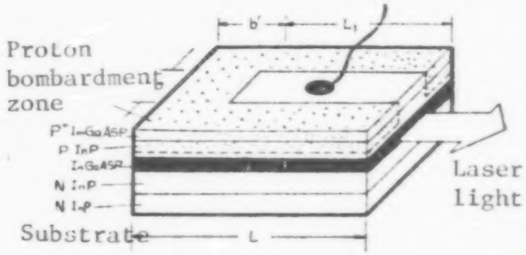
Proton
bombardment
zone
b'
L_1
P^+ InGaAsP
P InP
InGaAsP
N InP
N InP
Substrate
Laser
light
L

Figure 2. Schematic Diagram of the Structure of a Proton Bombarded InGaAsP/InP CCTS DH Laser

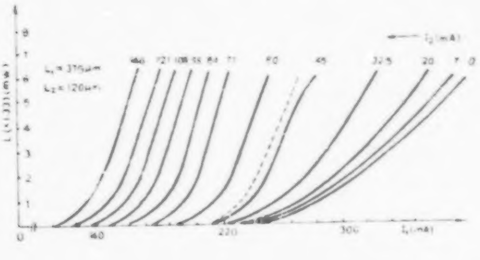

Figure 3. Light Intensity Versus Current $L-I_2-I_1$ Curves of 43 AlGaAs/GaAs CCTS DH Laser

We have analyzed the gain coefficient g (positive or negative) of the source zone of the laser using a linear approximation[3]:

$$g=\beta(J-J_0) \qquad J>J_0 \qquad (1)$$

$$g=\beta'(J-J_0) \qquad J<J_0 \qquad (2)$$

where J_o is the zero gain intercept current density and β and β' are two states of the source zone. Experimentally we have proven that the ratio

$$\zeta=\beta'/\beta$$

is greater than 1. The analysis results show as follows:

1. When J_2 J_o, I_{th1} and I_2 satisfy the following relationship

$$I_{th1}+I_2=I_{th0} \qquad \text{(constant)} \qquad (3)$$

2. When J_2 J_o, we have

$$I_{th1}+\zeta I_2=I_{th0}+(\zeta-1)I_0 \qquad (4)$$

Experimental results agree with (3) and (4) very well. These two equations can, therefore, be used as a basis for selecting the injection current to control the operation of the CCTS.

Figure 4 shows the L-I_1-I_2 curve of another CCTS laser. Judging from the parallel injection characteristics curves (dashed lines), the laser is operating in the multiwire mode[4], and there are two kinks in the curve. It is well known that nonlinearity is a major problem that is yet to be overcome in optical communication. Transient noise may lead to bit errors. In the CCTS laser shown in Figure 4, however, the power at the kink will move up when LD_2 is supplied with a low voltage and maintains a negative gain. The output characteristics of the laser are therefore improved considerably in the required power range.

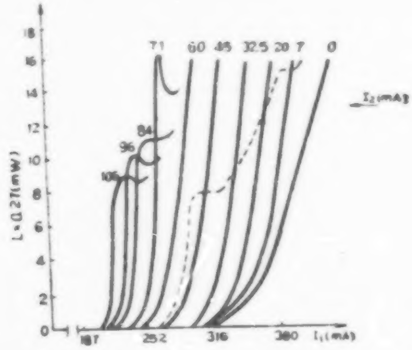

Figure 4. Light Intensity Versus Current L-I_2-I_1 Characteristics of the 22 AlGaAs/GaAs CCTS DH Laser

Atomically bombarded strip lasers generally have a wider strip-width (10-15 μm) and are more likely to have nonuniform multiwire problems. They may have some variations in their effective bandgap (and therefore the emitted wavelength). At a low injection voltage (low electron density), the refractive index of the material is mainly determined by the dielectric constant of the crystal, and wires with a small bandgap have a large dielectric constant and therefore a large refractive index. Conversely, a large bandgap corresponds to a small refractive index. Because of the step in refractive index at the boundary of the two adjacent fibers, the one with the smaller bandgap will become a constraint waveguide and the one with the larger bandgap will become a drain waveguide. The optical limiting factors $\Gamma(1) > \Gamma(2)$. With other parameters remaining the same, the threshold current density $J_{th}^{(1)}$ for stimulated emission of l_1 with the smaller bandgap is smaller than $J_{th}^{(2)}$ of l_2. In addition, they also satisfy the following relationship:

$$J_{th}^{(1)}/J_{th}^{(2)} = \Gamma(2)/\Gamma(1) \tag{5}$$

As a result, l_1 first emits short wavelength and operates in the single wire mode with a linear output. Then, as the injection current increases, l_1 begins to have stimulated recombination and, since the lifetime of the injected carriers is very short (10^{-9} sec), the electron density in the conduction band no longer increases, neither does the effective refractive index. However, l_2 has not reached the threshold and its electron density increases with the injection current, becoming more and more a gain waveguide. The constraint waveguide behavior of l_1 gradually decreases until l_2 has stimulated emission. If we write $\Delta I_{th} = I_{th}^{(2)} - I_{th}^{(1)}$, then the kink occurs in the transition region and there may even be a dip or a negative effective differential efficiency. If ΔI_{th} is small, the kink will occur "earlier" (at a lower power). On the other hand, a large ΔI_{th} will cause the kink to occur at a higher power and the laser will remain in the single wire mode for a greater injection current and have a greater range of linear power output.

Beginning with the CCTS steady state continuity equation, the threshold currents of l_1 and l_2 can be found and ΔI_{th} is therefore given by

$$\Delta I_{th} = \frac{A}{\beta}\left[\frac{1}{\Gamma(2)} - \frac{1}{\Gamma(1)}\right] + \frac{\beta'(2) - \beta'(1)}{\beta}(I_0 - I_2), \quad I_2 < I_0 \tag{6.a}$$

$$\Delta I_{th} = \frac{A}{\beta}\left[\frac{1}{\Gamma(2)} - \frac{1}{\Gamma(1)}\right], \quad I_2 > I_0 \tag{6.b}$$

where $\beta'(2)$ and $\beta'(1)$ are the negative gain linear approximation factors of l_1 and l_2 respectively. For a given emission wavelength, the second term in (6.a) is always positive since $\beta'(2) > \beta'(1)$. The positive gain linear approximation factor β may be regarded as the same for l_1 and l_2. A is a parameter that determines the threshold current and depends on the internal parameters of the device. Therefore, ΔI_{th} of the CCTS may be increased if I_2 is made smaller than I_0, the "kink" power will be moved up, the linear output range will be greater and the light source requirements for optical communication will be easier to satisfy.

III. Pulse Sequence of CCTS

Some semiconductor lasers may have sustained spontaneous pulse outputs at a certain current due to various physical causes such as mode conversion, optical inhomogeneity in the cavity and unstable transverse mode conversion. The occurrence of such pulses are not controllable and it limits the application of semiconductor lasers in high speed communication. People have tried various methods to suppress such pulses. However, if the generation of such pulses can be controlled, they can actually be a microwave self-modulation output or even CW output (the repetition rate is usually a few hundred to a few thousand megahertz), and may have great potential in other applications.

In the 1960's Bascov[5] has studied the transient behavior of homojunction GaAs laser which at the time could only be operated at low temperature (77K). We have made some preliminary observation of the transient behavior of CCTS DH lasers. Figure 5 shows the measured results of 55 AlGaAs/GaAs CCTS DH laser. To prove that such light pulses are not "spontaneous," we have operated the laser with two zones in parallel and found no light pulses. When the two zones were powered separately, we obtained the results in Figure 5.

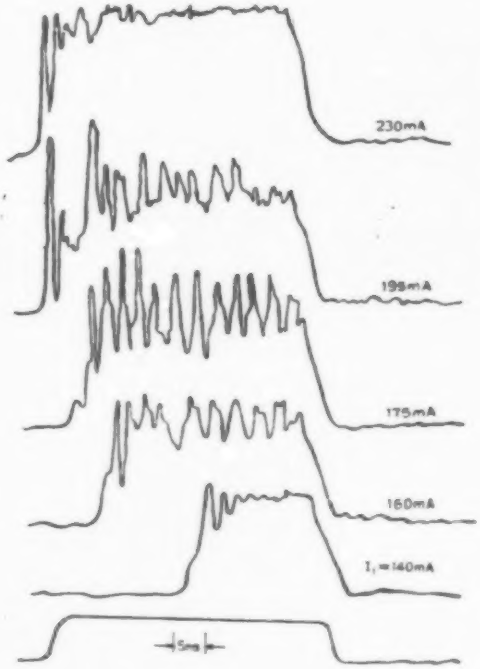

Figure 5. Transient Characteristics of 55 AlGaAs/GaAs CCTS DH Laser at I_2 = 215 mA

The electron and photon densities of the source zone in the CCTS laser satisfy the following rate equations:

$$\frac{dn_1}{dt} = \frac{J_1}{qd} - g_1 S - \frac{n_1}{\tau} \qquad (7)$$

$$\frac{dn_2}{dt} = \frac{J_2}{qd} - g_2 S - \frac{n_2}{\tau} \qquad (8)$$

$$\frac{dS}{dt} = (g_1 + kg_2)V_E S + \frac{\gamma}{\tau}(n_1 + kn_2)V_E - \frac{S}{\tau_p} \qquad (9)$$

$$g_1 = \langle\beta\rangle(n_1 - n_0) \quad g_2 = \langle\beta'\rangle(n_2 - n_0)$$

Here $k = L_2/L_1$, $V_E = L_1/(L_1 + L_2)$, γ is the spontaneous radiation factor, τ is the spontaneous recombination life of the electron, τ_p is the lifetime of the photon in the cavity, g_1, g_2 are the gain coefficients in LD_1 and LD_2 respectively, n_1 and n_2 are the electron density in LD_1 and LD_2, and J_1 and J_2 are respectively the injection current densities in LD_1 and LD_2 (not counting the spontaneous radiation term in Eq.(9)). Under the small signal condition of Basov (actually representing fast decay light pulses), the condition for the generation of light pulses is

$$\begin{aligned} &g_1 = g_{th} \quad g_2 < 0 \\ \text{i.e.}\ &I_1 \geq I_{th1} \quad I_2 < I_0 \end{aligned} \qquad (10)$$

We analyzed the large signal approximation for producing equal amplitude spontaneous pulses and found it to be

$$\begin{aligned} j_1 + \frac{k}{\zeta}[\zeta^2 + \zeta + 1]\, j_2 < \left(1 + \frac{1}{\zeta}\right)[k(\zeta - 1)j_0 + (k+1)j_{th0}] - \frac{j_0}{\zeta} \\ j_1 > j_{th0} \end{aligned} \qquad (11)$$

here j_1 and j_2 are the injection current densities in LD_1 and LD_2 respectively, j_{tho} is the threshold current density for parallel injection, and j_o is the zero gain current density. Figure 6 shows the pulse operation region in phase space based on the conditions (10) and (11). The area shaded by dashes is the current region for producing equal amplitude pulses in the CCTS. The experimental results are not yet in agreement with the theoretical prediction (dots in the figure) and further research is needed. Nevertheless, Figure 6 shows that the light pulse sequence can be controlled as long as the operating condition of the CCTS is properly chosen.

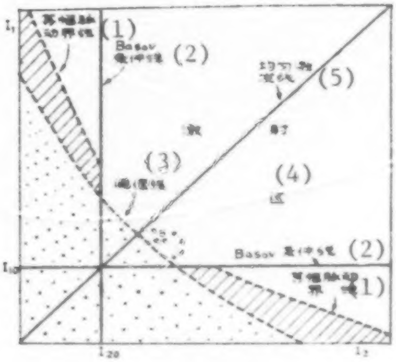

Figure 6. Pulsing Operation Region of CCTS DH Laser in the Phase Plane

Key:

1. Boundary for constant amplitude pulse
2. Basov condition line
3. Threshold line
4. Stimulated emission region
5. Uniform stimulation line

IV. Bistable Characteristics of the CCTS Output

Bistable light output is one of the research topics of current interest. A number of ways have been devised to produce bistable characteristics in the light output, CCTS DH lasers may prove to be an important, simple, and practical method. Optical flipflops may be developed into miniaturized solid state optical enhancement relays in optical communication and their optical logic function may also serve as the basis of optical computers. An optical flipflop of practical value must have sufficient dynamic range, sufficiently fast response and stable output modes.

Figures 7 and 8 show the bistable characteristics[6] of two InGaAs/InP CCTS devices fabricated according to the structure of Figure 2. When the current I_1 increases from zero, CCTS begins with spontaneous radiation and the optical output follows the path of the low state. When I_1 exceeds $I_1(1)$, CCTS DH suddenly gives off stimulated emission due to the action of the internal Q switch. The output light intensity abruptly jumps to the high state S(1) and then follows the path of the high state. When the current is decreased, since the CCTS cavity has already gone through a phase change and is filled with photons, the output returns along the high state path and the stimulated emission is present until I_1 drops below $I_1(2)$, and the intensity S(2) suddenly drops to zero. $\Delta I = I_1(1) - I_1(2)$ is the dynamic range of the current and in this range CCTS has bistable characteristics.

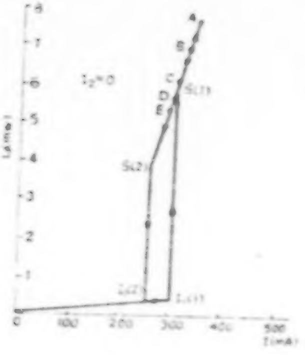

Figure 7. Bistable Characteristics of 83-A1 InGaAs/InP CCTS DH Laser Output

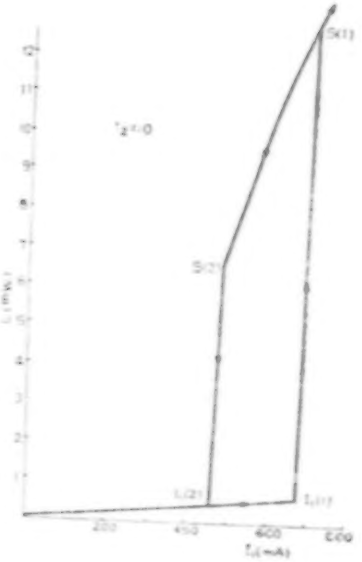

Figure 8. Bistable Characteristics of 83-815 InGaAs/InP CCTS DH Laser Output

Treating Eqs. (7), (8), and (9) as simultaneous equations and ignoring the contribution of the spontaneous radiation, we obtain the steady state photon density (S) of the CCTS:

$$S\left\{K_1\langle\beta\rangle\frac{J_1-J_0}{qd(1+\langle\beta\rangle\tau S)}+K_2\langle\beta'\rangle\frac{J_2-J_0}{qd(1+\langle\beta'\rangle\tau S)}-\frac{1}{\tau\tau_p}\right\}=0 \tag{12}$$

$$K_1=V_g \quad K_2=kV_g \quad J_0=\frac{qn_0d}{\tau}$$

Valid solutions of Eq.(12) are $S \geqslant 0$.

Let $J_2 = 0 < J_o$ and follow the analysis in Ref.[7], we have

$$J_1(1)=J_0(1+\zeta k)+\frac{qd}{\langle\beta\rangle\tau\tau_pV_g} \tag{13}$$

$$J_1(2)=(1+k)J_0+\left(\frac{1}{\langle\beta\rangle}-\frac{1}{\langle\beta'\rangle}\right)\frac{qd}{\tau\tau_pV_g}+2\left[\left(\frac{1}{\langle\beta\rangle}-\frac{1}{\langle\beta'\rangle}\right)\frac{kqdJ_0}{\tau\tau_pV_g}\right]^{1/2} \tag{14}$$

$$\Delta J=J_1(1)-J_1(2)=k(\zeta-1)J_0+\frac{qd}{\langle\beta'\rangle\tau\tau_pV_g}-2\left[\left(\frac{1}{\langle\beta\rangle}-\frac{1}{\langle\beta'\rangle}\right)\frac{kqdJ_0}{\tau\tau_pV_g}\right]^{1/2} \tag{15}$$

where d is the thickness of the source zone, and q is the electronic charge. As can be seen, the value of Δ J depends on k (= L_2/L_1). Equation (15) may serve as a reference for device design. According to the theoretical analysis of Ref.[7], (15) is valid only when $L_2 > 0$.

Figure 9 shows the output spectrum of the high state of one of the CCTS described above. It is significant that CCTS maintains a rather stable frequency output over a wide range of current. The halfwidth of the spectral line is $\Delta\lambda < 3$Å, the resolution limit of the equipment. The stability of the peak wavelength is as high as 10^{-5}. This is a very stable single frequency light source and very valuable in both optical communication and in signal processing.

We have measured the transient response of the CCTS and found that, except for a relatively long delay (about 50 ns, smaller at higher currents), the response time is of the order of ns. Making use of this, we adjusted the width and amplitude of the stimulating pulse and obtained single ultrashort pulse outputs from the CCTS. The pulse width is at most 500 ps (limited by the bandwidth of the oscilloscope). The result is shown in Figure 10.

Our experiments show that CCTS lasers, as an optical bistable device, have good potentials in their output characteristics, current dynamic range, spectral mode, and response speed.

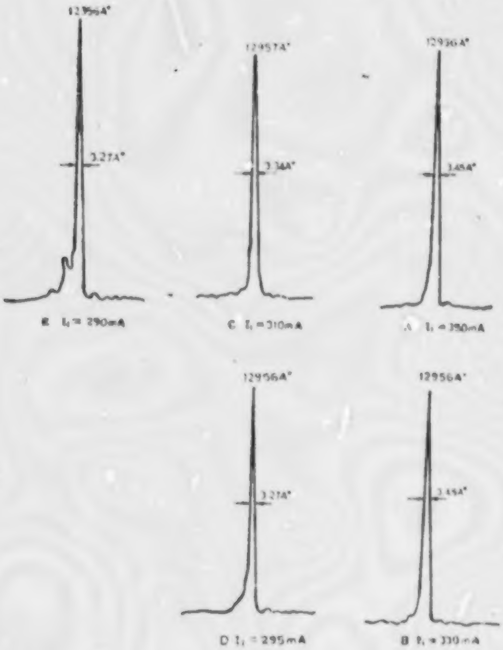

Figure 9. Stimulated Emission Spectrum of the 83-Al InGaAs/InP CCTS in the High State Under a Different Current ($I_2 = 0$) and at 300K

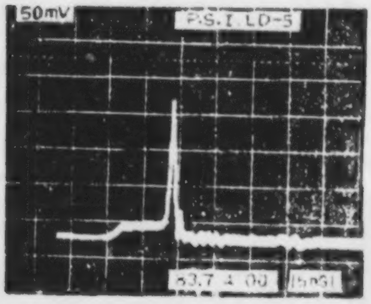

Figure 10. Single 500 ps Light Pulse From a InGaAs/InP CCTS Laser (horizontal axis 5 ns per division)

Conclusion

The two types of CCTS DH lasers described here have simple structures and the fabrication technique has also matured. Judging from the measurement results obtained to date, it already has a number of useful features and functions. Of particular interest is that the optical bistable function may be applied to optical enhancement relays in optical communication and may also serve as the basic unit in optical logic operations. To meet the requirements in practical applications, we must continue improving the structure of the device and further reduce the threshold current and the power consumption.

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APPLIED SCIENCES

DEVELOPMENT OF SECTIONAL CONSTRICTED PLANAR CO-CAVITY DH LASERS

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 6 No 4, Jul 85 pp 442-445

[Article by Du Guotong [2629 0948 0681], Jilin University; Yang Deling [2799 1795 2651], Chongqing Institute of Optoelectronic Technology and Gao Dingsan [7559 7844 0005], Jilin University; manuscript received 16 Oct 84]

[Text] This article reports the development of sectional constructed planar co-cavity DH lasers. At present lasers with a cavity length of 135μm and DC threshold values of 30mA (27°C) have been manufactured. Initial hypotheses for analyzing the mode characteristics for equivalent values over the whole cavity are suggested.

Not long ago in this journal, the manufacture and special characteristics of a new kind of refraction-steered and gain-steered laser of co-cavity structure, i.e., the sectional constricted planar co-cavity laser (SCP), designed and reported by us in [1]. This kind of laser has good linear light-power/current-flow curves, and compared with pure ridge-waveguide constricted lasers (CDHs) can preserve a larger power range in base horizontal mode and pure vertical mode operation. Because of limiting circumstances, at that time the lasers' current thresholds were still rather high.

To reduce the current thresholds and raise the reliability of the lasers, to make this kind of laser more practical, we carried out a great deal more experimental work, using improved extruded powder to make the epitaxies, improving the quality of the epitaxial layers. At the same time, adjustments were made in the rate of heat dissipation of the epitaxial layers and in the thickness of each layer, and a shorter cavity structure was used. At present we have already manufactured batch quantities of SCP lasers with thresholds of 30-40mA that can continuously operate at room temperature; the overall cavity length of the lasers is 90-150μm, the CDH section occupying 1/3-2/3. Figure 1 gives the light-power curves of several of those lasers. The two with the lowest threshold values are 852#, with an overall cavity length L=90μm, CDH section cavity length Lc=40μm, a tube-core pulse threshold of 25mA, and direct current threshold value of 29mA (22°C) and 821# with L=135μm, Lc=65μm, and 27°C direct current threshold of 30mA. To give a comparative explanation of the stability of SCP lasers in the lateral mode, the light-power curve of an oxide DH laser of the same width shows deviation in the power curve at about 2-3mW.

To observe the SCP laser's ability to preserve good linearity of the light-power curve in high power ranges, we turned the output power of some lasers to above 18mW, and they still manifested good linearity, as Figure 2 shows.

Previously we carried out observations of the near-field pattern of the SCP lasers. This time we carried out tests of the SCP lasers' far-field patterns. The tests made clear that the light beams outputted by the face of the two cavities showed good single peaks, the angle of divergence was within the range of 8-13°, and the base-mode oscillation could be preserved at 2-2.5 times the threshold value, about in the range of 15mW, as Figure 3 shows.

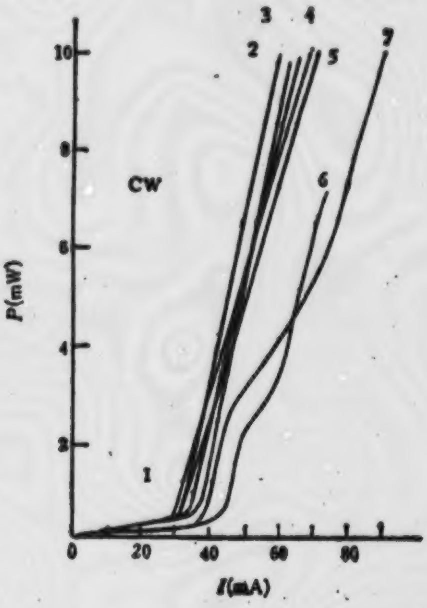


Figure 1. Light-power/current-flow curves for SCP and OS lasers with the same epitaxial layers: (1) SCP#852 (2) SCP#821 (3,4,5) SCP lasers (6,7) OS lasers

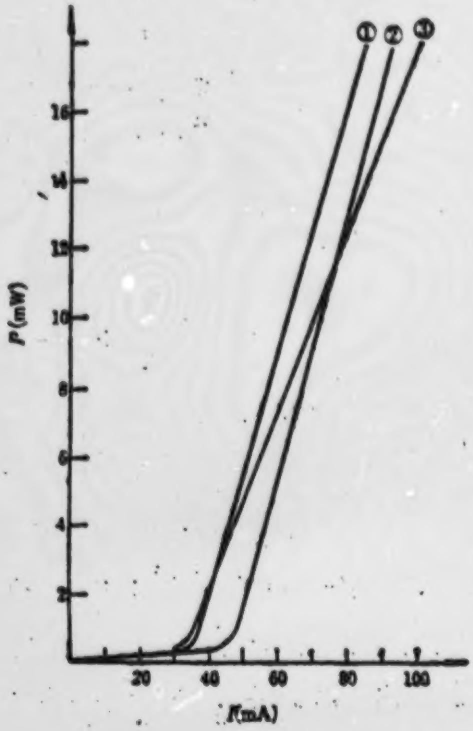
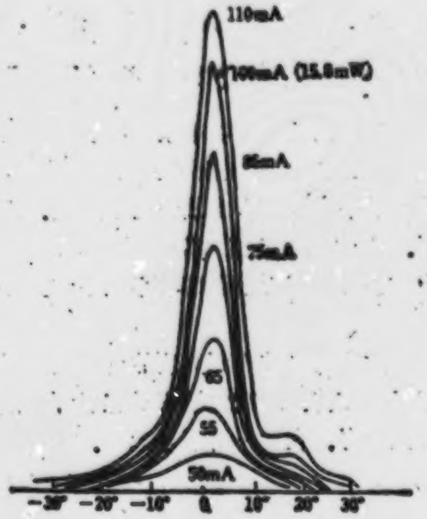


Figure 2. Light-power curves of SCP lasers: (1) SCP#037 (2) #040 (3) #039

We also carried out aging screenings on some of the lasers, under conditions of room temperature (about 25°C) at a steady 2mW output for 150 hours, with a rate of change of less than 5 percent. The screening results made clear that SCP lasers can have high reliability, and that their ratio of [acceptable] finished products can on the whole equal that of proton bombardment DH lasers. In Figure 4 we give the current-change curve of the 646# SCP laser operating continuously with a 2mW output at 25°C. It can be seen that after the laser was operating more than 96 hours, the working current needed for a 2mW output did not increase. According to consistent experience with proton bombardment laser aging screenings, a laser with this kind of steady performance ordinarily has a life exceeding 5,000 hours.



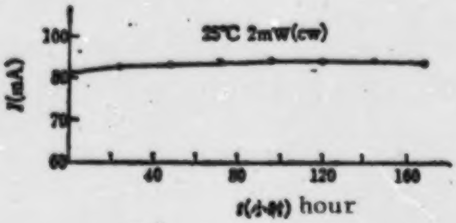


Figure 4. Changes over time in the operating current during aging of SCP laser 646#

Figure 3. Far-field light-intensity distribution of SCP lasers, tested at 30°C with a 1:14 pulse/duty ratio

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Using theory to interpret the lateral-mode stability and selectivity of SCP-structure lasers is an important topic, because the SCP laser structure involves three-dimensional changes, but present models of laser theory are all two-dimensional. This way, one must either expand two-dimensional models to the three-dimensional situation, or simplify the three-dimensional situation to a two-dimensional model for treatment. Now we hypothesize $\bar{n}_{C,eq}(\gamma)$ as the CDH section's effective rate of refraction, $\bar{n}_{O,eq}(\gamma)$ as the equivalent rate of refraction in the OS section. In regard to a light wave from a completely certain propagation model, the phase velocity in the CDH section $v_C = \frac{c}{\bar{n}_{C,eq}}$, the OS section's phase velocity $v_O = \frac{c}{\bar{n}_{O,eq}}$.

Thus the time required for a certain equal-phase face to pass through the two sections is $\tau_C = \frac{L_C}{v_C} = \frac{L_C}{c}\bar{n}_{C,eq}$, $\tau_O = \frac{L_O}{c}\bar{n}_{O,eq}$. If the reflection, diffraction and other phase changes at the interface of the CDH and OS sections are ignored, the time required for the equal-phase face to pass through the whole resonant cavity

$$\tau = \tau_O + \tau_C = \frac{L_C}{c}\bar{n}_{C,eq} + \frac{L_O}{c}\bar{n}_{O,eq}$$

Now we define a physical quantity called whole-cavity equivalent refraction,

$$\bar{n}_{s,eq} = \frac{L_C}{L}\bar{n}_{C,eq} + \frac{L_O}{L}\bar{n}_{O,eq}$$

and have $$\tau = \frac{L_C}{c}\bar{n}_{C,eq} + \frac{L_O}{c}\bar{n}_{O,eq} = \frac{L}{c}\bar{n}_{a,eq}$$

It can be seen that na,eq can equivalently characterize some waveguide characteristics of the SCP laser. Defining another physical quantity, called the whole-cavity average gain:

$$g(y) = \frac{L_C}{L}g_C(y) + \frac{L_O}{L}g_O(y).$$

At the same time we bring out the two hypotheses below: first, the sectional refraction gain-steering co-cavity laser's lateral mode selectivity and waveguide strength is determined by the $\bar{n}_{a,eq}(y)$ change regularity. Second, the condition for stability in the lateral mode that $\frac{\Delta\bar{n}}{\bar{n}} + \frac{\Delta g}{g} > 0$ can have $\bar{n}$ and g replaced by the whole-cavity equivalent values and average values, hence $\frac{\Delta\bar{n}_{a,eq}}{\bar{n}_{a,eq}} + \frac{\Delta g}{g} > 0.$ In this way we can qualitatively make clear the existence of the OS section in the SCP laser, causing a retardation in the relative changes of $\bar{n}_{a,eq}(y)$ and the CDH section's $\bar{n}_{C,eq}(y)$ in relation to γ, and from this improving the selectivity of the lateral mode. Similarly from the CDH section's existence throughout the process of the SCP laser's operation there is a positive $\frac{\Delta\bar{n}_{a,eq}}{\bar{n}_{a,eq}}$ in existence, which can overcome the problem of the OS section steering mechanism changing at low power levels and producing deviation in the power curve. Of course if the CDH section ratio is too small, insufficient to overcome the change in the OS section steering mechanism, the laser will also produce deviation in the power curve at low power levels, since the power level that manifests deviation and the ratio occupied by the CDH section are related. The complex three-dimensional situation can be treated this way by simplifying it into a two-dimensional model. In summary, by adjusting the cavity-length ratio of the CDH and OS sections the strength of the built-in waveguide and the power level that manifests deviation in the power curve can be conveniently adjusted, which is easy to realize technologically.

The Chongqing Institute of Optoelectronic Technology's Yang Liansheng [2799 6647 3932], Hu Enzhi [7579 1869 1807], etc. comrades participated in the experimental work, and Chief Engineer Zhang Renjun [1728 0088 0689] gave enthusiastic support. Guo Changzhi [6753 7022 1807], teacher at Beijing University, gave extremely great encouragement to the work and concrete guidance in the theoretical analysis. For this we all express our gratitude.

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APPLIED SCIENCES

OUTPUT POWER EQUATION AND NUMERICAL INTEGRATING METHOD OF POSITIVE-BRANCH UNSTABLE CONFOCAL RESONATOR

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 5, No 11, Nov 85 pp 986-991

[Article by Cheng Zuhai [4453 4371 3189] and Li Zaiguang [2621 0375 0342], Laser Institute, Huazhong University of Science and Technology, and He Xuhui [0149 3563 6540], Department of Physics, National Defence Institute of Science and Technology, Wuhan: "Output Power Equation and Numerical Integrating Method of a Positive-branch Unstable Confocal Resonator"]

[Text] Text of English Abstract: The output power equation of a positive-branch unstable confocal resonator was deduced by using the numerical integrating method and dividing the resonator to two regions. The numerical results of this equation are in good agreement with experimental data.

I. Introduction

The unstable resonator has been widely used in high power lasers for its large hengmu [2897 2875 transverse mode?] volume and excellent quality of its output beam. Research on unstable resonators has generally focused on analysis of the oscillation mode in the chamber and research on its output characteristics has rarely been reported, because there are great difficulties in mathematics in solving fresnel diffraction integral equations which will satisfy the self-consistent field within the chamber. This paper proceeds from the characteristics of positive-branch confocal unstable resonator oscillations, divides the oscillation optical field within the chamber into two regions, one in which there are plane waves and spherical waves overlapping and one in which there are only plane waves, and employing electromagnetic field theory of optical resonance chambers, uses the hypotheses of paraxial approximation and uniform gain distribution and deduces a mathematical equation of output power by the zone integration method. Carrying out numerical computations one a PDP-11/70 computer using this equation, we obtained theoretical computations results which fit the experimental data. The outstanding advantages of using this zone integration method are that it saves computer time and reduces the volume of computations, it has practical value for computations of positive-branch confocal unstable resonator output and efficiency and for correctly selecting

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optical chamber parameters. The positive-beam confocal resonator designed on the basis of the computational results on an HGL-84 type 5kW CO_2 laser obtained satisfactory results of a basic mode output power of 3.8 kW, and electron optical conversion efficiency reached 9.8 percent.

II. Theoretical Deduction of Output Power Equation

As illustrated in Figure 1, the positive-beam confocal unstable resonator's pair of self-reproducing modes are, respectively, a rightward propagated spherical wave with point of origin at virtual confocal point O and a leftward propagated plane wave with point of origin at an infinitely remote location. Their wave vectors are expressed as k_1 and k_2, respectively. When the resonance field in the chamber is axially symmetrical, the compound amplitudes of the spherical wave and the plane wave respectively are:

$$E_1(z, r, t)=\frac{g(z, r, t)}{\sqrt{z^2+r^2}}\exp\left(ik\sqrt{z^2+r^2}-i\omega t\right), \qquad (1)$$

$$E_2(z, r, t)=f(z, r, t)\exp[-i(kz+\phi)-i\omega t], \qquad (2)$$

in which, $k=|\boldsymbol{k}_1|=|\boldsymbol{k}_2|=\frac{2\pi}{\lambda}$, $g(z, r, t)/\sqrt{z^2+r^2}$, $f(z, r, t)$ are the amplitude functions of the spherical wave and the plane wave, respectively, and   is the initial phase of the plane wave.

The overall optical field E within the chamber

$$\begin{aligned}E(z, r, t)&=E_1(z, r, t)+E_2(z, r, t)\\&=\left\{\frac{g(z, r, t)}{\sqrt{z^2+r^2}}\exp\left(ik\sqrt{z^2+r^2}+f(z, r, t)\exp[-i(kz+\phi)]\right\}\exp(-i\omega t),\end{aligned} \qquad (3)$$

is the overlapping of the two waves.

In the coordinate system illustrated in Figure 1, the curved surface equations of lenses M_1 and M_2 are expressed as

$$\begin{cases}z=\sqrt{4(d+L)^2-r^2}-(d+L), & (4)\\ z=\sqrt{4d^2-r^2}-d_0 & (5)\end{cases}$$

According to standing wave conditions, the field intensity of the lens surface at M_1 and M_2 is zero, and taking Eqs. (4) and (5) into consideration, under paraxial approximation conditions:

$$\begin{cases}4d^2-r^2\doteq 4d^2,\\ 4(d+L)^2-r^2=4(d+L)^2\end{cases}$$

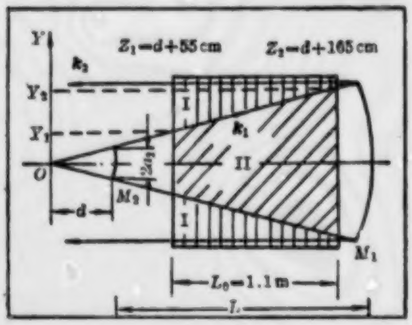


Figure 1. Divided regions and propagating waves in a positive-branch confocal unstable resonator
I: plane wave only;
II: both spherical and plane waves

we can find the relationship between phase and the amplitude of the spherical wave and the plane wave which satisfies:

$$\begin{cases} g(d+L,\ r,\ t) = -f(d+L,\ r,\ t) \\ \qquad\qquad \times (d+L), & (6) \\ g(d,\ r,\ t) = -f(d,\ r,\ t)\cdot d, & (7) \\ \phi = -2k(L+d)\text{。} & (8) \end{cases}$$

Taking Eq. (8) into consideration, when z>d, equation (3) can be rewritten:

$$E(z,\ r,\ t) = \left\{\frac{g(z,\ r,\ t)}{z}\exp\left[ik\left(z+\frac{r^2}{2z}\right)\right] + f(z,\ r,\ t)\exp[-ik(z-2d-2L)]\right\}\exp(-i\omega t)\text{。} \tag{9}$$

In a gain medium, the general form wave equation can be expressed as [1]:

$$\nabla^2 E = c^{-2}\frac{\partial^2 E}{\partial t^2} - c^{-1}G\frac{\partial E}{\partial t}, \tag{10}$$

in which c is the speed of light, G is the gain coefficient of the laser's working medium.

Ignoring the influence of the diffraction amplitude distribution, after lengthy mathematical deductions we obtained the field distribution given for Eq. (9)

$$\begin{cases} \dfrac{\partial g}{\partial z} = -\dfrac{1}{2}Gg, & (11) \\ \dfrac{\partial f}{\partial z} = \dfrac{1}{2}Gf\text{。} & (12) \end{cases}$$

The matrix form for the above equations is:

$$\begin{pmatrix} \dfrac{\partial g}{\partial z} & \dfrac{1}{2}g \\ \dfrac{\partial f}{\partial z} & -\dfrac{1}{2}f \end{pmatrix}\begin{pmatrix} 1 \\ G \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \tag{13}$$

i.e.,

$$\frac{\partial f}{\partial z}g + \frac{\partial g}{\partial z}f = 0\text{。} \tag{14}$$

the original function form is:

$$f(z,\ r)\cdot g(z,\ r) = c(r)\text{。} \tag{15}$$

Introducing functions $\theta(z), f_o(r)$, and letting them satisfy:

$$\begin{cases} f(z, r)=f_0\exp[\theta(z)], & (16) \\ \theta(d+L)=0. & (17) \end{cases}$$

From Eqs. (6),(7), (15) and (16) we get

$$\begin{cases} c(r)=-(d+L)\cdot f_0^2(r), & (18) \\ c(r)=-d\cdot f_0^2(r)\exp[2\theta(r)], & (19) \\ \dfrac{L+d}{d}=\exp[2\theta(d)]. & (20) \end{cases}$$

Note the geometrical magnification $M=\frac{L+d}{d}$, the positive-beam confocal unstable resonator, therefore Eq. (2) can be changed to:

$$\frac{1}{2}\ln M=\theta(d). \qquad (21)$$

Substituting Eqs. (16) and (18) in Eq. (15), we get:

$$g(z, r)=-(d+L)f_0(r)\exp[-\theta(z)]. \qquad (22)$$

In the HGL-84 cross-flow electron excitation CO_2 laser which we studied, the gas pressure was above 90 Torr, the gain coefficient G of the medium can be expressed as:

$$G=\frac{G_0}{1+I/I_s}, \qquad (23)$$

in which I is the light intensity, I_s is the saturation light intensity, and G_0 is the small signal gain coefficient.

For ease of analysis, we divided the resonance chamber into regions I and II. From Figure 1 it can be seen that in region II there was coexistence of plane wave f(z,r) and spherical wave g(z,r), while in region I there was only plane wave f(z,r). Clearly, the oscillating light intensity of regions I and II can be expressed respectively as:

$$\begin{cases} I_1(z, r)=f^2(z, r), & (24) \\ I_2(z, r)=f^2(z, r)+\dfrac{1}{z^2}g^2(z, r). & (25) \end{cases}$$

Taking into account Eqs. (12), (23), and (24), the oscillating light intensity in region I can be expressed as

$$\frac{\partial I_1(z, r)}{\partial z}=\frac{I_1(z, r)G_0}{1+\dfrac{I_0(z, r)}{I_s}}. \qquad (26)$$

Solving this equation we can both obtain the light intensity on the emergent cross-section of the positive-beam confocal unstable resonator and also find the laser output power. However, Eq. (26) can only be solved under given boundary conditions of a common I and II boundary. Thus it is necessary first of all to find the plane wave amplitude function f(z,r) in region II.

The equation in region II can be obtained from Eqs (12), (23), and (25):

$$\frac{\partial f(z,r)}{\partial z}=\frac{1}{2}G_0\left[1+\frac{f^2(z,r)+z^{-2}g^2(z,r)}{I_s}\right]^{-1}\cdot f(z,r). \qquad (27)$$

Under paraxial approximation conditions, let $\xi=\frac{z}{L}$, take into account $\frac{z}{L+d}=\frac{z}{L}\left(1-\frac{1}{M}\right)$, then the above equation can be further rewritten:

$$\frac{d\theta(\xi)}{d\xi}=\frac{1}{2}G_0L\Big/\left\{1+\frac{f_0^2}{I_s}\left[e^{2\theta(\xi)}+\frac{1}{\xi^2\left(1-\frac{1}{M}\right)^2}e^{-2\theta(\xi)}\right]\right\}. \qquad (28)$$

The above question is a first order differential equation which contains the special specific coefficient f_o, and must have two boundary condition equations (16) and (21) to be solved. After parameter conversion, equation (26) becomes

$$\frac{\partial I_1(\xi,r)}{\partial\xi}=I_1(\xi,r)\cdot L\cdot G_0\Big/\left[1+\frac{I_1(\xi,r)}{I_s}\right]. \qquad (29)$$

Noting that $J_1=I_1/I_s$, the above equation becomes:

$$\frac{\partial J_1(\xi,r)}{\partial\xi}=J_1(\xi,r)\frac{G_0L}{1+J_1(\xi,r)}. \qquad (30)$$

The boundary conditions of Eq. (30) can be given in the form f(z,r) after solution of Eq. (28) through conversion of Eq. (16). After the solution $J_1(\xi,r)$ of Eq. (30) is found, the output power equation of the positive-branch confocal unstable resonator is as follows:

$$P_{out}=2\pi I_s\int_{a_1}^{Ma_1}dr\cdot r\cdot J_1\left(\xi=\frac{d}{L},r\right). \qquad (31)$$

III. Computation Method and Results

The key to solving the positive-branch confocal unstable resonator output power Eq. (31) is solving Eq. (28). But Eq. (28) is a first order non-linear ordinary differential equation with a very high degree of non-linearity and is very difficult to find an analytic solution. We used the fourth order Runge-Kutta method to carry out the numerical computations but before computing, we first used a computer search method to compute a series of $\theta(z_2/L)$ f_o, to make it close to $\frac{1}{2}\ln(M)$, and when we reached a predetermined precision, found the specific constant f_o and solving Eq. (28) could obtain $\theta(\xi)$, making the conversion of equation (16) for the $\theta(\xi)$ already found, converting it to function f (z), i.e., carry out numerical computation of output power equation (31).

From Figure 1 it can be seen that in regions I and II, when $\xi<z_1/L$ or $\xi>z_2/L$ the medium gain is zero, but when $a_2<r<r_1-a_2\frac{z_1}{L}(M-1)$ we have

$$J_1(\xi-d/L,\ r)=J_1(\xi,\ r)=[f_0e^{g(\xi)}]^2/I_s=Mf_0^2/I_{s0} \qquad (32)$$

When $Ma_2>r>r_2-a_2\cdot\frac{z_2}{L}(M-1)$ we have

$$J_1(\xi-d/L,\ r)=J_1(z_1/L,\ r_2)。 \qquad (33)$$

Taking the above conditions into consideration, Eq. (31) can finally be rewritten

$$P_{out}=2\pi I_s\left[\int_{a_2}^{r_1}+\int_{r_1}^{r_2}+\int_{r_2}^{Ma_2}\right]dr\cdot r\cdot J_1(\xi-d/L,\ r)$$

$$=2\pi I_s\left[\frac{r_1^2-a_2^2}{2}Mf_0^2/I_s+\int_{r_1}^{r_2}dr\cdot r\cdot J_1(\xi-d/L,\ r)+\frac{(Ma_2)^2-r_2^2}{2}J_1(z_1/L,\ r_2)\right]。 \qquad (34)$$

Using compound hualupushen [0553 3764 2528 3932] formula to carry out numerical integration on the integral terms of Eq. (34) in $r\xi[r_1,r_2]$ region, numerical computation of the efficiency and output power of any positive-branch confocal unstable resonator can be carried out. Figure 2 corresponds to the two types positive-branch confocal unstable resonator structures of HGL-84 type transverse flow electron excitation CO_2 laser, in a chamber 2m long, with output coupled lens opening diameters a_2=25mm, M=1.67 and 1.4, corresponding to the average gain distribution pattern illustrated in Figure 3, the theoretical computation curve of the output characteristics of the two experimental unstable resonator obtained using equation (34).

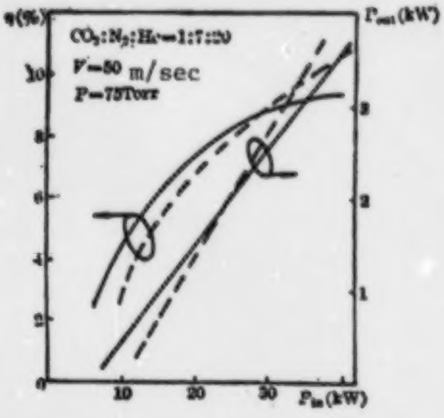


Figure 2. Theoretical curves of the output characteristics of the unstable confocal resonator used in experiments (lines: M = 1.07; dots: M = 1.4)

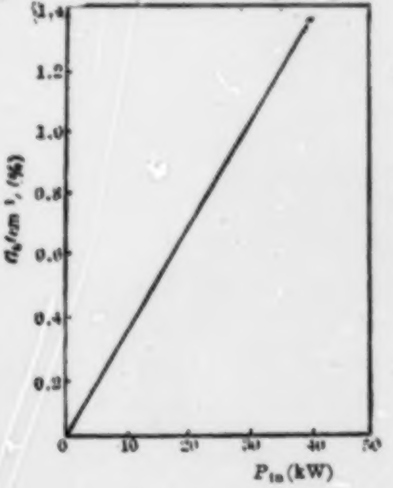


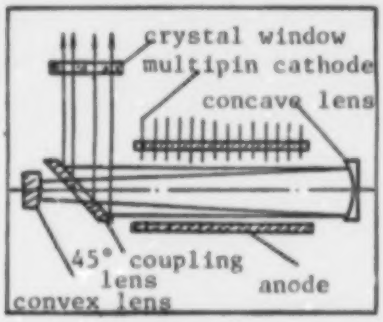
Figure 3.

Small signal gain G_0 versus imput power P_{in} of a model HGL-84 CO_2 laser

IV. Comparison of Theoretical and Experimental Data

Experimental researches on output characteristics of an HGL-84 transverse flow CO_2 laser using the confocal unstable resonator structure illustrated in Figure 4. Typical optical chamber parameters of the experimental chamber were:

Figure 4. Schematic diagram of the confocal unstable resonator



Chamber length L=2m, inner diameter of the 45° coupled output lens d_2=25mm, the radii R_2 and R_1 of the convex lens and the concave lens curvature satisfied the confocal condition of $R_1-R_2=2L$, so that its geometrical magnification $M=R_1/R_2$ satisfies this chamber's equivalent Fresnel number:

$$N_{eq}=\frac{M-1}{2}\cdot\frac{a_2^2}{\lambda L}$$

is the semi odd number condition which is favorable for selecting the transverse mode.[2]

Figures 5(a) and (5) are, comparisons of the theoretical computation and experimental data curves of efficiency and output power of the experimental resonator with, respectively, M=1.4 and M=1.67 positive-branch confocal unstable resonators under conditions of a gaseous flow velocity of 50m/sec, an operating gas pressure of 90 Torr, with a gas mixture ratio of CO_2:N_2:He=1:7:20.

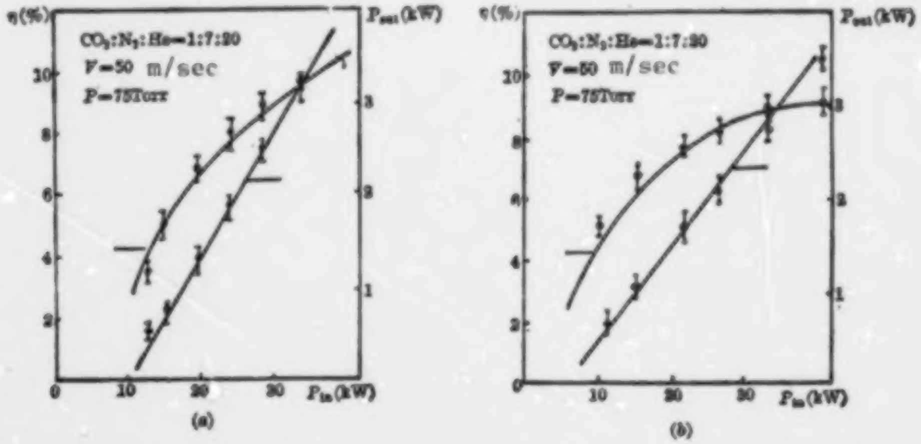


Figure 5. Theoretical (lines) and experimental (dots) output characteristics of the confocal unstable resonator

(a) M=1.4; (b) M=1.67

From Figure 5 it can be seen that the output characteristics of the positive-branch confocal unstable resonator computed using Eq. (34) can fit fairly well with the experimental results. It can be seen that using positive-branch confocal unstable resonator output power Eq. (31) derived from zone integration method has theoretical and practical value, especially for rational selection of optical chamber parameters and provides a reliable mathematical basis.

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APPLIED SCIENCES

CHARACTERISTIC OF VANE-LOADED HELIX SLOW-WAVE STRUCTURE

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 11, No 5, Sep 83 pp 23-32

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[Text] English Abstract: Based on the existing vane-loaded helix slow-wave structure, a theoretical analytic model is proposed, in which the space between the helix and metallic barrel is fully filled up with dielectric, and vanes, infinite in number and infinitely thin in thickness, are set along all over the inner wall of the barrel. By utilizing the matching method of regional electromagnetic field for individual regions, the electromagnetic field distribution in the space of three respective regions is found. And the dispersion equation, couple impedance and attenuation constant are then obtained.

This paper also discusses the propagation system of electromagnetic wave, with S being the cross section of any shape. A principle of stored energy equalization is derived from the above discussion. Then rods of any shape can be made equivalent to that of wedge shape and, thus, ε_{eff} can be obtained through the equation of $\varepsilon_{eff}-1=a(\varepsilon_r-1)$. Being free from any supplementary conditions, this method of dielectric treatment may be generalized and applicable to all sorts of slow-wave structure supported by dielectric rods of any shape and nature. A series of practical slow-wave structures are designed according to the above model. The calculated values are found to be in good agreement with the measured values.

1. Introduction

The vane-loaded helix slow-wave structure has been actually applied in dual mode TWT and wideband high power TWT. Tubes with this structure have some excellent characteristics. In addition to preserving basically the unchanged 4:1 electron injection within the bandwidth and wave asynchronous parameters, the nonlinear characteristics within the wideband, the compression characteristics of saturation time and power, and the relative shape of gain curves at different injection currents all were improved. In addition, under certain conditions, loading is lighter compared to isotropic metallic screen loading and longitudinal line conductive screen loading; compared with the longitudinal line, it can suppress fast wave transmission; compared with some special dielectric holding rod loading it is better suited to high power applications. Thus vane-loading is a good method for improving TWT performance.

As concerns the dispersion characteristics of vane-loaded helix slow-wave structure, there are many analytical articles [1-4], but most do not treat the dielectric rod. Although reference [4] uses the pure surface area equivalency method to treat the dielectric rod, it overlooks the difference in electromagnetic field between a gapped dielectric ring and ungapped dielectric ring. Moreover, the theoretical bases of the pure surface equivalency method is that the electromagnetic field of the space in which the dielectric is situated is evenly distributed which does not conform to reality.

The analysis in this paper is based on such an axially symetrical model, the region between the helix and the metallic barrel is filled with dielectric, in this region are placed in infinite number of longitudinal vanes of a certain diameter, infinitely thin, and having infinitely large conductivity (see Figure 1); in the region where the vanes are situated there is only an angular electric field. We considered overall the influence of the dielectric and the conductor and solved for the characteristics of vane-loaded helix structure. When solving ε_{eff} for the actual holding rod shape, we did our processing very strictly, proceeding from the principle of stored energy equality. The results of computations for dispersion characteristics conform to the results of wideband measurements of different actual structures. This computational method not only can be used for vane-loaded structures, but also has universal significance for other metallic screen loading and dielectric rod loading of a section of any shape.

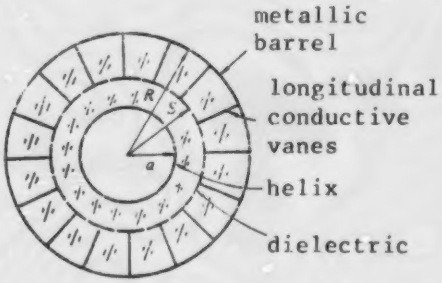


Figure 1 Analytical model

II. Theoretical Analysis

The analytical model of the actual vane-loaded helix slow-wave structure is illustrated in Figure 1. The entire structure is divided into three regions: region I, $0 \leqslant r \leqslant a$, $\varepsilon_1 \mu_1$; region II, $a \leqslant r \leqslant s$, $\varepsilon_2 \mu_2$ region III, $s \leqslant r \leqslant R$, $\varepsilon_3 \mu_3$. ε_i, μ_i . (i=1,2,3) are the dielectric constant and magnetic inductivity of the dielectric in the three regions respectively; r is the columnar coordinate radius; a is the radius of the conducting surface spiral; s is the radius of the top of the vane; R is the inner radius of the barrel. Using the conducting surface spiral model considers only the electromagnetic field in the regions of the minimum times model (n=0) as:

$$\left.\begin{aligned}
E_{zi}&=[A_iI_0(\gamma_ir)+B_iK_0(\gamma_ir)]\exp j\,(\omega t-\beta_iz)\\
H_{zi}&=[C_iI_0(\gamma_ir)+D_iK_0(\gamma_ir)]\exp j\,(\omega t-\beta_iz)\\
E_{ri}&=\frac{j\beta_i}{\gamma_i^2}\,\frac{\partial E_{zi}}{\partial r},\quad i=1,\ 2,\ 3\\
E_{\theta i}&=-\frac{j\omega\mu_i}{\gamma_i^2}\,\frac{\partial H_{zi}}{\partial r}\\
H_{ri}&=\frac{j\beta_i}{\gamma_i^2}\,\frac{\partial H_{zi}}{\partial r}\\
H_{\theta i}&=\frac{j\omega\varepsilon_i}{\gamma_i^2}\,\frac{\partial E_{zi}}{\partial r}
\end{aligned}\right.\qquad (1)$$

in which γ is the radial phase constant, $\gamma_i^2=\beta_i^2-k_i^2$; k_i is the free space phase constant, $k_i^2=\omega^2\mu_i\varepsilon_i$; β is the axial phase constant; $K_i(\gamma r)$ is the Bessel function of the second kind of order i of the zongliang [1350 6852] as γr . Since $\beta\gg k_i$, we know that $\gamma_1=\gamma_2=\gamma_3=\gamma$.

The boundary conditions of the regions are: when r=R, $E_T=0$; when r=s, $E_z=0$, and H_z/E_Θ continuously; when r=a,

$$E_{z1}=E_{z2},\ E_{\theta1}=E_{\theta2},\ E_{z1}\sin\psi+E_{\theta1}\cos\psi=0,\ H_{z1}\sin\psi+H_{\theta1}\cos\psi=H_{z2}\sin\psi+H_{\theta2}\cos\psi.$$

The natural boundary conditions are: $B_1=D_1=0$.

The solution to the electromagnetic field distribution for the region is:

$$\left.\begin{aligned}
E_{z1}&=AI_0(\gamma r)\\
H_{z1}&=-A\frac{j\gamma}{\omega\mu_1\operatorname{ctg}\psi}\,\frac{I_{0a}}{I_{1a}}I_0(\gamma r)\\
E_{r1}&=A\frac{j\beta_1}{\gamma}I_1(\gamma r)\\
E_{\theta1}&=-A\frac{I_{0a}}{I_{1a}\operatorname{ctg}\psi}I_1(\gamma r)\\
H_{r1}&=A\frac{\beta_1}{\omega\mu_1\operatorname{ctg}\psi}\,\frac{I_{0a}}{I_{1a}}I_1(\gamma r)\\
H_{\theta1}&=A\frac{j\omega\varepsilon_1}{\gamma}I_1(\gamma r)
\end{aligned}\right\}\qquad (2a)$$

$$\left.\begin{aligned}
E_{z2}&=A\left[I_0(\gamma r)-\frac{I_{0s}}{K_{0s}}K_0(\gamma r)\right]\Big/\left(1-\frac{I_{0s}K_{0a}}{K_{0s}I_{0a}}\right).\\
H_{z2}&=-A\frac{j\gamma}{\omega\mu_2\operatorname{ctg}\psi}\;\frac{I_{0a}}{I_{1a}}\left[1\Big/\left(1-\frac{I_{1R}K_{1a}}{K_{1R}I_{1a}}\right)\right]\left[I_0(\gamma r)+\frac{I_{1R}}{K_{1R}}K_0(\gamma r)\right]\\
E_{r2}&=A\frac{j\beta_2}{\gamma}\left[1\Big/\left(1-\frac{I_{0s}K_{0a}}{K_{0s}I_{0a}}\right)\right]\left[I_1(\gamma r)+\frac{I_{0s}}{K_{0s}}K_1(\gamma r)\right]\\
E_{\varphi 2}&=-A\frac{I_{0a}}{I_{1a}\operatorname{ctg}\psi}\left[1\Big/\left(1-\frac{I_{1R}K_{1a}}{K_{1R}I_{1a}}\right)\right]\left[I_1(\gamma r)-\frac{I_{1R}}{K_{1R}}K_1(\gamma r)\right]\\
H_{r2}&=A\frac{\beta_2}{\omega\mu_2\operatorname{ctg}\psi}\;\frac{I_{0a}}{I_{0a}}\left[1\Big/\left(1-\frac{I_{1R}K_{1a}}{K_{1R}I_{1a}}\right)\right]\left[I_1(\gamma r)-\frac{I_{1R}}{K_{1R}}K_1(\gamma r)\right]\\
H_{\varphi 2}&=A\frac{j\omega\varepsilon_2}{\gamma}\left[1\Big/\left(1-\frac{I_{0s}K_{0a}}{K_{0s}I_{0a}}\right)\right]\left[I_1(\gamma r)+\frac{I_{0s}}{K_{0s}}K_1(\gamma r)\right]
\end{aligned}\right\}\qquad\text{(2b)}$$

$$\left.\begin{aligned}
E_{z3}&=0\\
H_{z3}&=-A\frac{j\gamma}{\omega\mu_2\operatorname{ctg}\psi}\cdot\frac{I_{0a}}{I_{1a}}\left[1\Big/\left(1-\frac{I_{1R}K_{1a}}{K_{1R}I_{1a}}\right)\right]\left[I_0(\gamma r)+\frac{I_{1R}}{K_{1R}}K_0(\gamma r)\right]\\
E_{r3}&=0\\
E_{\varphi 3}&=-A\frac{\mu_3}{\mu_2\operatorname{ctg}\psi}\;\frac{I_{0a}}{I_{1a}}\left[1\Big/\left(1-\frac{I_{1R}K_{1a}}{K_{1R}I_{1a}}\right)\right]\left[I_1(\gamma r)-\frac{I_{1R}}{K_{1R}}K_1(\gamma r)\right]
\end{aligned}\right\}\qquad\text{(2c)}$$

in which I_i (γa) is the Bessel function of the first kind of order i of the independent variable γa, $I_{0a}=I_0\,(\gamma a)$, $I_{1a}=I_1\,(\gamma a)$; $I_{0s}=I_0\,(\gamma s)$, $I_{1R}=I_1(\gamma R)$, $K_{0s}=K_0(\gamma s)$, $K_{1R}=K_1(\gamma R)$.

The solution to the dispersion equation is:

$$\left(\frac{k_1}{\gamma}\operatorname{ctg}\psi\right)^2=\left[I_{0a}^2-\frac{\mu_1}{\mu_2}I_{0a}I_{1a}\frac{G_{01}(\gamma a,\ \gamma R)}{G_{11}(\gamma a,\gamma R)}\right]\Big/\left[I_{1a}^2-\frac{\varepsilon_2}{\varepsilon_1}I_{0a}I_{1a}\frac{G_{10}(\gamma a,\gamma s)}{G_{00}(\gamma a,\gamma s)}\right]\qquad(3)$$

in which $G_{01}(\gamma a,\ \gamma R)=I_{0a}K_{1R}+I_{1R}K_{0a};\ G_{11}\ (\gamma a,\ \gamma R)\ =I_{1a}K_{1R}-I_RK_{1a};\ G_{10}(\gamma a,\ \gamma s)\ =I_{1a}K_{0s}$ $+I_{0s}K_{1a};\ G_{00}(\gamma a,\ \gamma s)\ =I_{0a}K_{0s}-I_{0s}K_{0a};$

$\operatorname{ctg}\psi=\dfrac{2\pi a}{p}$, where a is the average radius of the helix, and p is the thread pitch.

If there are no vanes, s=R, then Eq. (3) changes to

$$\left(\frac{k_1}{\gamma}\operatorname{ctg}\psi\right)^2=\frac{I_{0a}^2-\dfrac{\mu_1}{\mu_2}I_{0a}I_{1a}\dfrac{G_{01}}{G_{11}}}{I_{1a}^2-\dfrac{\varepsilon_2}{\varepsilon_1}I_{0a}I_{1a}\dfrac{G_{10}}{G_{00}}}\qquad(4)$$

in which $G_{01}=I_{0a}K_{1R}+I_{1R}K_{0a};\quad G_{11}=I_{1a}K_{1R}-I_{1R}K_{1a};\quad G_{10}=I_{1a}K_{0R}+I_{0R}K_{1a};\quad G_{00}=I_{0a}K_{0R}-I_{0R}K_{0a}.$

This is the result of Gilmour *et al*.[5]

Finding the coupled impedance was essentially solving the system's overall power flow P_T. Finding the power flow of the regions as delineated in Figure 1, and using Eq. (2), we get:

$$P_T = P_1 + P_2 + P_3 = \frac{\pi A^2 \beta_1 k_1 a^2}{2\gamma^2 \sqrt{\mu_1/\varepsilon_1}} \cdot L_T \qquad (5)$$

in which

$$\begin{aligned}
L_T = {} & M(\gamma a)\Big[1 + \frac{\gamma^2}{k_1^2 \operatorname{ctg}^2\psi}\,\frac{I_{0a}^2}{I_{1a}^2}\Big] + \frac{\beta_2}{\beta_1}\,\frac{\varepsilon_2}{\varepsilon_1} I_{0a}^2 \Big[\Big(\frac{s^2}{a^2} M(\gamma s) - M(\gamma a)\Big)\Big(\frac{K_{0s}^2}{G_{0a,0s}^2} \\
& + \Big(\frac{\gamma}{k_2 \operatorname{ctg}\psi}\Big)^2 \frac{K_{1R}^2}{G_{1a,1R}^2}\Big) + 2\Big(\frac{s^2}{a^2} P(\gamma s) - P(\gamma a)\Big)\Big(\frac{I_{0s} K_{0s}}{G_{0a,0s}^2} \\
& - \Big(\frac{\gamma}{k_2 \operatorname{ctg}\psi}\Big)^2 \frac{I_{1R} K_{1R}}{G_{1a,1R}^2}\Big) + \Big(\frac{s^2}{a^2} N(\gamma s) - N(\gamma a)\Big)\Big(\frac{I_{0s}^2}{G_{0a,0s}^2} \\
& + \Big(\frac{\gamma}{k_2 \operatorname{ctg}\psi}\Big)^2 \frac{I_{1R}^2}{G_{1a,1R}^2}\Big)\Big] + \frac{\beta_3}{\beta_1}\,\frac{\varepsilon_3}{\varepsilon_1}\,\frac{s^2}{a^2} \\
& \cdot I_{0a}^2 \Big(\frac{\mu_3}{\mu_2}\Big)^2 \Big[\Big(\frac{R^2}{s^2} M(\gamma R) - M(\gamma s)\Big) \frac{K_{1R}^2}{G_{1a,1R}^2} \Big(\frac{\gamma}{k_3 \operatorname{ctg}\psi}\Big)^2 \\
& - 2\Big(\frac{R^2}{s^2} P(\gamma R) - P(\gamma s)\Big) \frac{I_{1R} K_{1R}}{G_{1a,1R}^2} \Big(\frac{\gamma}{k_3 \operatorname{ctg}\psi}\Big)^2 + \Big(\frac{R^2}{s^2} \\
& \cdot N(\gamma R) - N(\gamma s)\Big) \frac{I_{1R}^2}{G_{1a,1R}^2} \Big(\frac{\gamma}{k_3 \operatorname{ctg}\psi}\Big)^2\Big]
\end{aligned}$$

$G_{0a,0s} = I_{0a} K_{0s} - I_{0s} K_{0a}$; $G_{1a,1R} = I_{1a} K_{1R} - I_{1R} K_{1a}$; $M(x) = I_1^2(x) - I_0(x) I_2(x)$; $N(x) = K_1^2(x) - K_0(x) K_2(x)$; $P(x) = I_1(x) K_1(x) + I_0(x) K_0(x)$.

The impedance parameters are

$$\Big(\frac{E_{z0}^2}{\beta_1^2 P_T}\Big)^{1/3} = \Big(\frac{\gamma}{\beta_1}\Big)^{4/3} \Big(\frac{\beta_1}{k_1}\Big)^{1/3} \Big[\frac{(\gamma a)^2}{240} L_T\Big]^{-1/3} \qquad (6)$$

The average coupled impedance of the electron injection regions is

$$\overline{K}_{e,} = \frac{1}{2}\Big(\frac{\beta_1}{k_1}\Big)\Big(\frac{\gamma}{\beta_1}\Big)^4 [I_0^2(\gamma r_e) - I_1^2(\gamma r_e)] \Big[\frac{(\gamma a)^2}{240} L_T\Big]^{-1} \qquad (7)$$

in which r_e is the electron injection radius.

If there are no vanes, then $P_3=0$ and an expression P_T similar to Eq. (5), but the content of L_T in the equation is different.

$$P_T = \frac{\pi A^2 k_1 \beta_1 a^2}{2\gamma^2 \sqrt{\mu_1/\varepsilon_1}} L_T \qquad (8)$$

in which

$$\begin{aligned}
L_T = {} & M(\gamma a)\Big(1 + \frac{\gamma^2}{k_1^2 \operatorname{ctg}^2\psi}\,\frac{I_{0a}^2}{I_{1a}^2}\Big) + \frac{\beta_2}{\beta_1}\,\frac{\varepsilon_2}{\varepsilon_1} I_{0a}^2 \Big[\Big(\frac{R^2}{a^2} M(\gamma R) \\
& - M(\gamma a)\Big)\Big(\frac{K_{0R}^2}{G_{00}^2} + \Big(\frac{\gamma}{k_2 \operatorname{ctg}\psi}\Big)^2 \frac{K_{1R}^2}{G_{11}^2}\Big) + 2\Big(\frac{R^2}{a^2} P(\gamma R) \\
& - P(\gamma a)\Big)\Big(\frac{I_{0R} K_{0R}}{G_{00}^2} - \Big(\frac{\gamma}{k_2 \operatorname{ctg}\psi}\Big)^2 \frac{I_{1R} K_{1R}}{G_{11}^2}\Big) + \Big(\frac{R^2}{a^2} N(\gamma R) \\
& - N(\gamma a)\Big)\Big(\frac{I_{0R}^2}{G_{00}^2} + \Big(\frac{\gamma}{k_2 \operatorname{ctg}\psi}\Big)^2 \frac{I_{1R}^2}{G_{11}^2}\Big)\Big]
\end{aligned}$$

The attenuation constant a is defined as: $a = -\frac{1}{2P_T}\frac{dP_T}{dz}$. The rate of change axially in the total power flow of the electromagnetic wave transmitted along the axis of the system is equal to the power dissipated in section dz. Using the approximate boundary conditions of Leontovich and Eq. (2) we get:

$$\begin{aligned} a = \frac{k_2 R_{s1}}{\beta_1 a\sqrt{\mu_2/\varepsilon_2}}\frac{I_{0a}^2}{L_T}\frac{\varepsilon_2}{\varepsilon_1}\Big\{\Big[\Big(\frac{\varepsilon_1}{\varepsilon_2}\frac{I_{1a}}{I_{0a}}\Big)^2 + \Big(\frac{\gamma^2}{k_1^2 \operatorname{ctg}\psi}\Big)^2 \\ \cdot\Big(\frac{\varepsilon_1}{\varepsilon_2}\frac{I_{0a}}{I_{1a}}\Big)^2 + \Big(\frac{G_{1a,0s}}{G_{0a,0s}}\Big)^2 + \Big(\frac{\gamma^2}{k_2^2 \operatorname{ctg}\psi}\Big)^2\Big(\frac{G_{0a,1R}}{G_{1a,1R}}\Big)^2\Big] \\ + \frac{R_{s2}}{R_{s1}}\frac{s}{a}\Big[\Big(\frac{1}{\gamma_s}\Big)^2\Big(\frac{1}{G_{0a,0s}}\Big)^2 + 2\Big(\frac{\gamma^2}{k_2^2 \operatorname{ctg}\psi}\Big)^2\Big(\frac{G_{0s,1R}}{G_{1a,1R}}\Big)^2\Big] \\ + \frac{R_{s3}}{R_{s1}}\frac{R}{a}\Big(\frac{1}{\gamma R}\Big)^2\Big(\frac{1}{G_{1a,1R}}\Big)^2\Big(\frac{\gamma^2}{k_2^2 \operatorname{ctg}\psi}\Big)^2\Big\} \end{aligned} \tag{9}$$

where L_T in the equation and Eq. (5) are identical. R_{s1}, R_{s2}, and R_{s3} are the single phase length high frequency resistance of the helix, the vane top surface, and the barrel respectively. If there are no vanes, then Eq. (9) can be changed to

$$\begin{aligned} a = \frac{k_2 R_{s1}}{\beta_1 a\sqrt{\mu_2/\varepsilon_2}}\frac{I_{0a}^2}{L_T}\frac{\varepsilon_2}{\varepsilon_1}\Big\{\Big[\Big(\frac{\varepsilon_1}{\varepsilon_2}\frac{I_{1a}}{I_{0a}}\Big)^2 + \Big(\frac{\gamma^2}{k_1^2 \operatorname{ctg}\psi}\Big)^2\Big(\frac{\varepsilon_1}{\varepsilon_2}\frac{I_{0a}}{I_{1a}}\Big)^2 \\ + \Big(\frac{G_{10}}{G_{00}}\Big)^2 + \Big(\frac{\gamma^2}{k_2^2 \operatorname{ctg}\psi}\Big)^2\Big(\frac{G_{01}}{G_{11}}\Big)^2\Big] + \frac{R_{s3}}{R_{s1}}\frac{R}{a}\Big(\frac{1}{\gamma R}\Big)^2\frac{1}{G_{00}^2} \\ + \Big(\frac{\gamma^2}{k_2^2 \operatorname{ctg}\psi}\Big)^2\Big(\frac{1}{\gamma R}\Big)^2\frac{1}{G_{11}^2}\Big\} \end{aligned} \tag{10}$$

L_T in the equation and Eq. (8) are identical.

III. Some Problems of Numerical Computations

The actual helix slow-wave structure is as illustrated in Figure 2. The computational formulas in the preceding section cannot be applied directly, but the equivalency dielectric constant ε_{eff} must be found from an actual structure.

First we discuss the general situation. Suppose an electromagnetic wave transmission system, section S is of any shape, place dielectric of section ΔS along the axis of this system, the section shape and dielectric characteristics are all arbitrary, then we can prove (see Appendix) that the system transmission constant placed in front of and behind the dielectric has the following relationship:

$$\beta - \beta_0 = \frac{\omega\int_{\Delta S}(\varepsilon - \varepsilon_0) E\, E_0^* dS}{c\int_S (E_0^* \times H + E \times H_0^*) e_z dS} \tag{11}$$

the denominator represents the system's power flow, the numerator represents the change in stored energy after the dielectric is placed in the column of section ΔS.

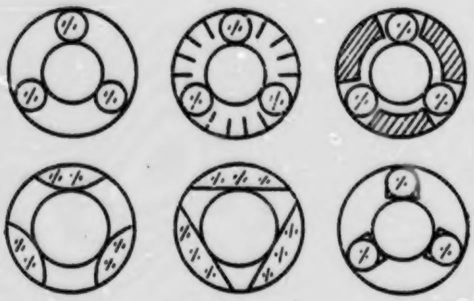


Figure 2. Actual helix slow-wave structure

For the actual vane-loaded structure (Figure 3), it was only necessary to consider circular rods of the part $B_2F_2D_2C_1F_0A_1$. We thought that with the phase constant of a vane-loaded structure of dielectric of the shape $A_2F_2C_2C_1F_0A_1$ as β_0, the system phase constant after placing a dielectric of section S_2 as β_2, and the system phase constant after placing a dielectric of section S_1 as β_1, then the condition $\beta_2=\beta_1$ which we could get according to Eq. (11) was the stored energy equality of dielectric S_1 and S_2, i.e.,

$$\int_{S_1} E_1 E_0^* dS = \int_{S_2} E_1 E_0^* dS \tag{12}$$

Thus, the dielectric rod of the shape $B_2F_2D_2C_1F_0A_1$ can be equivalent to the fan-shaped rod which has angle Θ, then we can solve

$$\varepsilon_{eff} - 1 = (\varepsilon_r - 1)\frac{N\theta}{2\pi} \tag{13}$$

N in the equation is the number of dielectric rods.

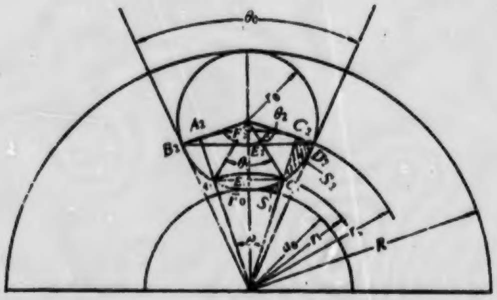

θ_0
r_0
θ_2
A_2
C_2
B_2
F_2
E_2
θ_1
D_2
S_2
A_1
E_1
C_1
F_0
S_1
r_1
r_2
R

Figure 3. Actual vane-loaded structure

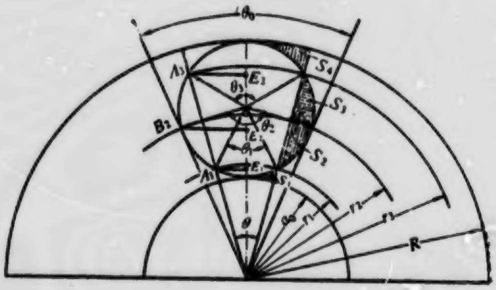

θ_0
A_3
E_3
θ_3
S_4
S_3
B_2
θ_2
E_2
θ_1
S_2
A_1
E_1
S_1
θ
r_1
r_2
r_3
R

Figure 4. Actual non-vaned structure

From the geometrical diagram we can get

$$2S_1=\frac{1}{2}\theta(r_1^2-a_0^2)-\left[\frac{1}{2}(\theta r_1^2+\theta_1 r_0^2)-\overline{A_1E_1}(a_0+r_0)\right] \qquad (14)$$

in which $\theta=2\sin^{-1}\frac{\overline{A_1E_1}}{r_1}$, $\theta_1=2\sin^{-1}\frac{\overline{A_1E_1}}{r_0}$, $A_1E_1=\frac{1}{2(r_0+a_0)}\sqrt{(r_1^2-a_0^2)(R^2-r_1^2)}$

$$2S_2=\frac{1}{2}(\theta_0 r_s^2+\theta_2 r_0^2)-\overline{B_2E_2}(a_0+r_0)-(r_s^2-a_0^2)\frac{\theta}{2}-2S_1 \qquad (15)$$

in which $\overline{B_2E_2}=\frac{1}{2(r_0+a_0)}\sqrt{(r_s^2-a_0^2)(R^2-r_s^2)}$, $\theta_0=2\sin^{-1}\frac{\overline{B_2E_2}}{r_s}$, $\theta_2=2\sin^{-1}\frac{\overline{B_2E_2}}{r_0}$

From Eq. (2) we can find the average field strength of the two regions $a_0\leqslant r\leqslant r_1$ 及 $r_1\leqslant r\leqslant r_s$.

$$\left.\begin{aligned}\overline{E_z(\mathrm{I})}&=\frac{1}{\gamma^2(r_1^2-a_0^2)}\left[2A\Big/\left(1-\frac{I_{0s}K_{0a}}{K_{0s}I_{0a}}\right)\right]\Big\{[\gamma r_1 I_1(\gamma r_1)\\&\quad-\gamma a_0\cdot I_1(\gamma a_0)]-\frac{I_{0s}}{K_{0s}}[\gamma r_1 K_1(\gamma r_1)-\gamma a_0 K_1(\gamma a_0)]\Big\}\\\overline{E_z(\mathrm{II})}&=\frac{1}{\gamma^2(\gamma_s^2-r_1^2)}\left[2A\Big/\left(1-\frac{I_{0s}K_{0a}}{K_{0s}I_{0a}}\right)\right]\Big\{[\gamma r_s I_1(\gamma r_s)\\&\quad-\gamma r_1\cdot I_1(\gamma r_1)]-\frac{I_{0s}}{K_{0s}}[\gamma r_s K_1(\gamma r_s)-\gamma r_1 K_1(\gamma r_1)]\Big\}\end{aligned}\right\} \qquad (16)$$

Solving Eqs. (12), (14), (15) and (16) together we can find Θ.

For structures without vanes, we must consider the entire circular holding rod, which can be divided into four regions: $a_0\leqslant r\leqslant r_1$, $r_1\leqslant r\leqslant r_2$, $r_2\leqslant r\leqslant r_3$, and $r_3\leqslant r\leqslant R$ (Figure 4).

The average field strength of the regions respectively is:

$$\left.\begin{aligned}\overline{E_z(\mathrm{I})}&=\frac{1}{\gamma^2(r_1^2-a_0^2)}\;\frac{2AI_{0a}}{I_{0a}K_{0R}-K_{0a}I_{0R}}\{K_{0R}[\gamma r_1 I_1(\gamma r_1)-\gamma a_0 I_1(\gamma a_0)]\\&\quad+I_{0R}[\gamma r_1 K_1(\gamma r_1)-\gamma a_0 K_1(\gamma a_0)]\}\\\overline{E_z(\mathrm{II})}&=\frac{1}{\gamma^2(r_2^2-r_1^2)}\;\frac{2AI_{0a}}{I_{0a}K_{0R}-K_{0a}I_{0R}}\{K_{0R}[\gamma r_2 I_1(\gamma r_2)-\gamma r_1 I_1(\gamma r_1)]\\&\quad+I_{0R}[\gamma r_2 K_1(\gamma r_2)-\gamma r_1 K_1(\gamma r_1)]\}\\\overline{E_z(\mathrm{III})}&=\frac{1}{\gamma^2(r_3^2-r_2^2)}\;\frac{2AI_{0a}}{I_{0a}K_{0R}-K_{0a}I_{0R}}\{K_{0R}[\gamma r_3 I_1(\gamma r_3)-\gamma r_2 I_1(\gamma r_2)]\\&\quad+I_{0R}[\gamma r_3 K_1(\gamma r_3)-\gamma r_2 K_1(\gamma r_2)]\}\\\overline{E_z(\mathrm{IV})}&=\frac{1}{\gamma^2(R^2-r_3^2)}\;\frac{2AI_{0a}}{I_{0a}K_{0R}-K_{0a}I_{0R}}\{K_{0R}[\gamma R I_1(\gamma R)-\gamma r_3 I_1(\gamma r_3)]\\&\quad+I_{0R}[\gamma R K_1(\gamma R)-\gamma r_3 K_1(\gamma r_3)]\}\end{aligned}\right| \qquad (17)$$

From the geometrical figure we can find:

$$2S_1=\frac{1}{2}\theta(r_1^2-a_0^2)-\left[\frac{1}{2}(\theta r_1^2+\theta_1 r_0^2)-\overline{A_1E_1}(a_0+r_0)\right] \quad (18)$$

in which, $\theta=2\sin^{-1}\frac{\overline{A_1E_1}}{r_1}$, $\theta_1=2\sin^{-1}\frac{\overline{A_1E_1}}{r_0}$, $\overline{A_1E_1}=\frac{1}{2(r_0+a_0)}\sqrt{(r_1^2-a_0^2)(R^2-r_1^2)}$

$$2S_2=\frac{1}{2}\pi(\theta_0 r_2^2+\theta_2 r_0^2)-\overline{B_2E_2}(a_0+r_0)-\frac{\theta}{2}(r_2^2-a_0^2)+2S_1 \quad (19)$$

in which $\overline{B_2E_2}=\frac{1}{2(r_0+a_0)}\sqrt{(r_2^2-a_0^2)(R^2-r_2^2)}$, $\theta_0=2\sin^{-1}\frac{\overline{B_2E_2}}{r_2}$, $\theta_2=2\sin^{-1}\frac{\overline{B_2E_2}}{r_0}$

$$2S_3=\pi r_0^2-\left[\frac{1}{2}(\theta_0 r_2^2+\theta_2 r_0^2)-\overline{B_2E_2}(r_0+a_0)\right]-\frac{1}{2}(R^2-r_2^2)+2S_4 \quad (20)$$

$$2S_4=\frac{1}{2}(R^2\theta-r_0^2\theta_3)-\overline{A_3E_3}(r_0+a_0) \quad (21)$$

in which $\overline{A_3E_3}=\frac{1}{2(r_0+a_0)}\sqrt{(r_3^2-a_0^2)(R^2-r_3^2)}$, $\theta_3=2\sin^{-1}\frac{\overline{A_3E_3}}{r_0}$, $\theta=2\sin^{-1}\frac{\overline{A_3E_3}}{r_3}$

$$=2\sin^{-1}\frac{\overline{A_1E_1}}{r_1}.$$

On the basis of the condition of stored energy equality, $2S_1\overline{E_z(\mathrm{I})^2}=2S_2\overline{E_z(\mathrm{II})^2}$ and $2S_3\overline{E_z(\mathrm{III})^2}=2S_4\overline{E_z(\mathrm{IV})^2}$, , i.e., we can find Θ. In actual computations, one can discover that processing dielectric S_3 and S_4 is not really important, especially when γa is large (for example, $\gamma a>1.5$) it can be omitted. When γa is relatively small, processing this term can be treated as a correction term.

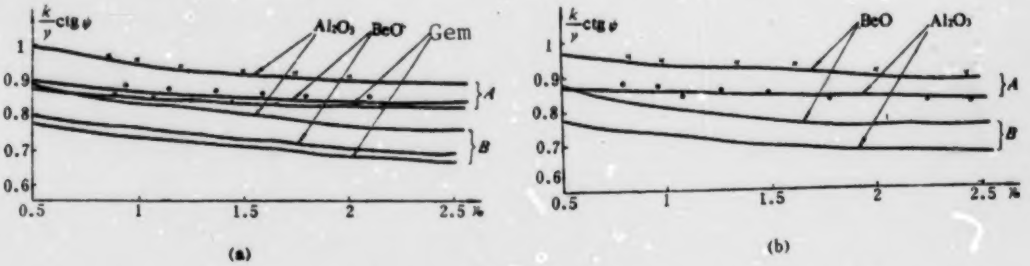
The actual structures of the other shapes in Figure 2 can be processed according to the above described principles. It should be noted that the application of Eq. (11) is correct only when the disturbances to the system's electrical field caused by the medium is not great and this conforms to the actual situation.

IV. Comparison of Computational Results and Experimental Results

To check the computation method, we selected helixes of three transverse dimensions, which corresponded to the typical dimensions of 10, 5, 3, and 2 mm wave segments respectively. We obtained measurement data by using the cold measurement and hot measurement methods within the range of 2-16GHz. The experimental model includes: filament wound and belt wound helixes, the influence of dielectric loading (variation of dielectric material and the dielectric rod geometric dimensions), the influence of metallic screen loading (isotropic metallic screens, longitudinal conductive screen, vane-loading), influence of number of vanes and radius of vane tops, influence of industrial technology (cold elastic pressure, thermal expansion, flash welding, and diffusion welding). The experimental data was drawn from the same system, the same power source and the same voltage meter. Figures 5 and 6 give partial results (curve A represents the computational values of this paper, curve B represents the computational values of the surface equivalence method, the symbols x#° and • represent the experimental values).

Synthesizing the great quantity of computational results and test results we can reach the following conclusions:

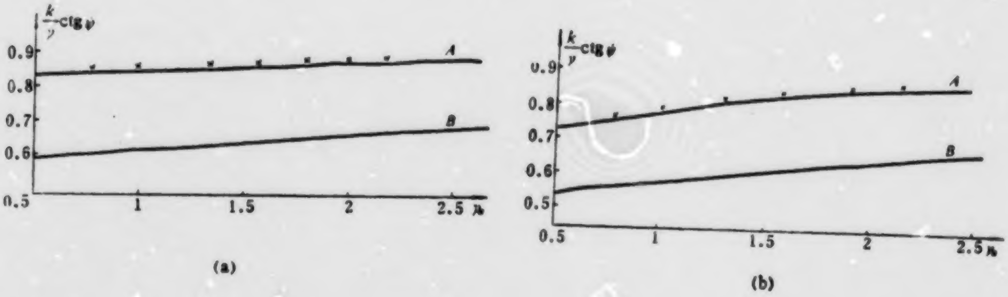
1. Theory and experiment both show that as far as practical vane-loaded TWT are concerned, using a great number of vanes and a large s/a value makes it effective. Thus, the analytical model in this paper not only comes close to the actual structure, but also the computations are handy.



(a)

(b)

Figure 5. Comparison of computational and experimental results for non-vaned structures



(a)

(b)

Figure 6. Comparison of computational and experimental results for vane-loaded structures

2. The characteristics of the actual slow-wave structure are determined by the space electromagnetic distribution of the structure. Using the concept of stored energy equality as a method for processing dielectric rods not only is theoretically strict, but the computational results also conform to actual measurements. There are no limitations on this method for dielectric performance and geometrical shape, thus there is universality. The ε_{eff} of a wedge-shaped rod substitutes for the dielectric ring's ε_r formula $\varepsilon_{eff}-1=(\varepsilon_r-1)\,\alpha,\ \alpha=N\theta/2\pi.$

In terms of shape, it seems that α is an area ratio, but actually it is stored energy concept results obtained under special conditions. If these special case errors are seen as universal principles, then there are problems in introducing the concept of the pure area equivalency of the dielectric rod.

In this paper we were guided and helped by Professor Wu Hongshi [0702 7703 6624], comrades from our laboratory did a great deal of tube manufacturing work and we should like to express our thanks here.

Appendix

Discussing an electromagnetic wave transmission system of section S, if a dielectric of section ΔS is placed along the axial direction of the system (as in Figure 7) then the electromagnetic field of the system changes from E_0H_0 to EH. ε and μ are equation definitions from B = μH and D = εE.

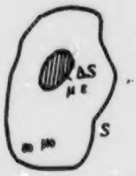


Figure 7. Transmission system of S section

For isotropic dielectrics, ε is the scalar; for anisotropic dielectrics, ε is the bipolar tensor, $D_i=\sum_{k=1}^{3}\varepsilon_{ik}E_k;$ for isotropic diamagnetic and paramagnetic bodies, μ is the scalar; for anisotropic ferromagnetic materials, μ is the second order tensor, $B_i=\sum_{k=1}^{3}\mu_{ik}H_k.$ Only when the dielectric is placed in the region inside S can the Kronecker symbol δ_{ik} be used.

$B = \hat{\mu}'H$ $\hat{\mu}'H$ representative component is the vector $\hat{\mu}'_{ik}H_k$

$D = \hat{\varepsilon}'E$ $\hat{\varepsilon}'E$ representative component is the vector $\hat{\varepsilon}'_{ik}E_k$

In ΔS $\mu'_{ik}=\mu_{ik},\ \varepsilon'_{ik}=\varepsilon_{ik};$ in $S-\Delta S,$ $\mu'_{ik}=\varepsilon'_{ik}=\delta_{ik}.$

According to Maxwell's equation

$$\nabla\times E=-\frac{1}{c}\ \frac{\partial B}{\partial t},\qquad \nabla\times H=\frac{1}{c}\ \frac{\partial D}{\partial t}$$

in a system which does not have dielectric ΔS placed in it,

$$E_0(x,y,z)=E_0(x,y)\exp j(\beta_0 z-\omega t),\quad H_0(x,y,z)=H_0(x,y)\exp j(\beta_0 z-\omega t),$$

thus we can get:

$$\nabla\times E_0(x,y)+j\beta_0\,(\mathbf{e}_z\times E_0(x,y))=\frac{j\omega\mu_0}{c}H_0(x,y)$$

$$\nabla\times H_0(x,y)+j\beta_0\,(\mathbf{e}_z\times H_0(x,y))=-\frac{j\omega\varepsilon_0}{c}E_0(x,y)$$

In a system after the dielectric ΔS is placed in it we can get:

$$\nabla\times E(x,y)+j\beta(\mathbf{e}_z\times E(x,y))=\frac{j\omega\hat{\mu}'}{c}H(x,y)$$

$$\nabla\times H(x,y)+j\beta(\mathbf{e}_z\times H(x,y))=-\frac{j\omega\hat{\varepsilon}'}{c}E(x,y)$$

$$\nabla\cdot(H\times E_0^*)+\nabla\cdot(H_0^*\times E)=j(\beta-\beta_0)(E_0^*\times H+E\times H_0^*)\cdot$$

$$\cdot\,\mathbf{e}_z-\frac{j\omega}{c}[(\hat{\varepsilon}'-\varepsilon_0)E\cdot E_0^*+(\hat{\mu}'-\mu_0)H\cdot H_0^*]$$

Taking the volume integral and using Gauss's theorem

$$\oint_s (H\times E_0^* + H_0^* \times E)\cdot n dS = 0$$

we get

$$\beta-\beta_0=\frac{\omega\int_{\Delta s}[(\hat{\varepsilon}-\varepsilon_0)E\cdot E_0^*+(\hat{\mu}-\mu_0)H\cdot H_0^*]dS}{c\int_s[E_0^*\times H+E\times H_0^*]\cdot e_z dS}$$

For isotropic non-magnetic dielectric rods it can be simplified to

$$\beta-\beta_0=\frac{\omega\int_{A},(\varepsilon-\varepsilon_0)E\cdot E_0^* d,}{C\int,(E_0^*\times H+E\times H_0^*)\cdot e_z dS}$$

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APPLIED SCIENCES

IMPROVEMENT OF LARGE SIGNAL INTERACTION MODEL FOR TWT

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[Article by Song Wenmiao [1345 2429 8693], Liu Yongquan [0491 3279 6898], and Wu Jingxian [0702 7234 6343], all of Institute of Electronics, Chinese Academy of Sciences*]

[Text] Abstract: Because of the nonconservation of energy in Rowe's model for large signal interaction in TWT, Towe's model produces considerable error in TWT design, especially for a velocity-tapered one. A modified model which is based on energy conservation is suggested to improve the accuracy of the design of TWT. By the new model, when the loss and space charge in TWT are neglected, the energy received by the circuit is exactly equal to that given by the electron beam. All the results obtained with the new model are in better agreement with the actual cases than those obtained with Rowe's model.

I. Introduction

Rowe's[1] theoretical model of helical TWT large signal interaction is still the most commonly used one in helical TWT design. As is pointed out in referenced [2-4], in Rowe's model there is the problem of non-conservation of energy, i.e., under ordinary circumstances, the energy received by the circuit is greater than the energy consumed by electron injection. References [4] discusses in particular detail the factors in non-conservation of energy and its relationship to some other factors. Analysis demonstrates that this energy difference is proportional to the gain parameter c and the idle component of the electron injection current's fundamental wave element. Therefore, as the electron injection's fundamental wave current increases, the energy difference also increases, that is, when the TWT work is near the asynchronous parameter $b = 0$, the influence of this energy non-conservation reaches its greatest point. And this state is the working state desired in phase velocity resynchronous technology.[5,6] Thus, to reflect more accurately the working state of a helical TWT under phase velocity tapering, it is necessary to improve Rowe's interaction model so that it can satisfy the universal laws of energy conservation.

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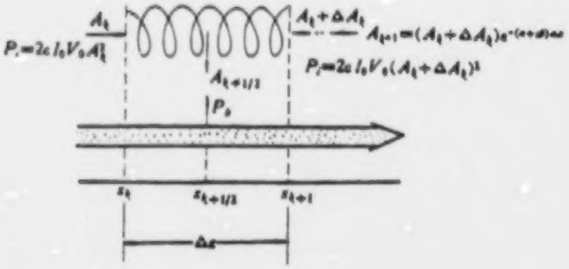
According to the analysis of reference [4], the basic reason that non-conservation of energy is produced is Rowe's equivalent lumped circuit and induced current mode. Thus we did not adopt the LC equivalent circuit model and voltage wave form, but made the field a variable directly. Nor did we adopt the induced current form for energy exchange, but made conservation of energy directly the basis for interaction between the field and electron injection. To make comparison easier, the new model still uses the normalization model and variable form used by Rowe, but similar variables here have a completely different significance. Comparing the computational results of the new model and Rowe's model one can see that (1) in the new model, energy is completely conserved, thus generally speaking, its efficiency is lower than Rowe's model, especially when $b = 0$, the difference is especially great. (2) In the new model, with similar input, the length of the action area required to reach saturation is slightly longer than in Rowe's model. (3) In the new model, the relationship of efficiency and asynchronous parameter is more acute than in Rowe's model, i.e., in the new model, as b changes, the change in efficiency is greater, especially when b approaches zero, efficiency drops faster than in Rowe's model. These points demonstrate that the new model conforms more closely to the actual situation than does Rowe's model.

II. Brief Account of the Physical Model

The physical model of interaction is illustrated in Figure 1. The figure presents the interaction situation within the area from z_k to z_{k+1}. Here $\hat{A}$ no longer represents voltage but directly represents the direct ratio to the "wave variable" of the electrical field. Because the backward wave is generally overlooked in the helical TWT, $\hat{A}$ is the direct wave. Here $\hat{A}$ is a complex number representing the amplitude and phase of the included wave. As a discretized method, we assume that the field between z_k and z_{k+1} is a constant, that is, there are no changes in amplitude and phase. After going through this area, a change occurs in the field, and this change comes about through superposition of two parts: (1) In this area electron injection excites the field, that is, as illustrated in Figure 1, the wave variable $\widehat{A_k}$ changes into $\widehat{A_k} + \Delta\widehat{A_k}$. This excitation $\Delta\widehat{A_k}$ can be found from the conservation of energy relationship, i.e., through computation letting $P_o = P_i + P_b$. (Here, P_o is the outlet power, P_i is the inlet power, P_b is the electron injection power.) (2) The attenuation and phase shift of the helix, i.e.,

Figure 1. TWT Interaction Model (all A_k in the figure are $\hat{A}_k$)


A_k
$P_i=2\varepsilon I_0V_0A_k^2$
$A_k+\Delta A_k$
$A_{k+1}=(A_k+\Delta A_k)e^{-(\alpha+i\beta)\Delta z}$
$P_o=2\varepsilon I_0V_0(A_k+\Delta A_k)^2$
$A_{k+1/2}$
P_b
z_k
$z_{k+1/2}$
z_{k+1}
Δz

$$\hat{A}_{k+1} = (\hat{A}_k + \Delta\hat{A}_k)e^{-(\alpha+i\beta)\Delta z}.$$

Here, Δz is the distance between z_k and z_{k+1}, that is, the step size obtained from computation. From this assumption we can know that the external force exerted by the electrons in this area does not change. Therefore it should be uniformly accelerated motion.

The overall computation steps are roughly as follows: first we compute the electron motion in the given field; from electron motion, through the conservation relationship of electron injection power P_b, inlet power P_i, and exit power P_o we compute $\Delta\hat{A}_k$; $\hat{A}_k$ is added to the original $\hat{A}_k$, and the electron motion is computed again; this is repeated until convergence. However, the results of actual computations demonstrate that for precision to one one-thousandth generally convergence can be achieved in two iterations. Furthermore, in the iteration process, the space charge force does not change; this is because it is determined by the distribution of the inlet's space charge plate, and since it is not necessary to recompute the space charge force, the time required for computation is not long. After computing $\Delta\hat{A}_i$, Eq. (1) is used to find the wave variable of the next point and so on step by step until the entire path is computed.

III. Electron Field Expression

In analysis of helical circuits, it is actually only the relationship between the field and the power flow that is analyzed, and the impedance of the helix is computed from this[7,8]. In large signal analysis we also directly apply the results of references [7 and 8]. From this it can be seen that directly making the field a variable to establish the relational expression of power flow, impedance, and the electrical field is much more rational than through voltage. Thus we adopted:

$$P = \frac{|\hat{E}|^2}{2\beta^2 Z_0},$$

Here, in line with commonly used symbols, P is the power flow, $\hat{E}$ is the electrical field, β is the phase constant, and Z_0 is the coupled impedance.

To facilitate a comparison with Rowe's model, we also used Rowe's normalized variables. The variables used in the paper and whenever the definitions of the variables used by Rowe are the same, we will not add any explanation. The two normalized independent variables are the normalized distance y and time φ_0:

$$y = \frac{c\omega}{u_0} z,$$

and

$$\varphi_0 = \omega t_0.$$

The definition of velocity is:

$$\frac{dz}{dt} = u_0[1 + 2cu(y, \varphi_0)].$$

When the wave variable $\hat{A}$ is defined, we maintain the efficiency expression:

$$\eta = 2c|\hat{A}|^2.$$

Thus, the normalized wave variable $\hat{A}$ can be defined:

$$\hat{A} = \frac{c}{Z_0 I_0 \beta}\hat{E},$$

Here, β is the phase constant of the cold circuit wave and not the phase constant of the hot wave in Rowe's model.

$$\beta = \frac{\omega}{u_0}(1 + bc).$$

IV. Electron Field Equations

Since we used the same normalized system, we adopted wholesale the expression of the space charge field from Rowe's book and changed only the expression of the high frequency field:

$$E_{rf} = \mathrm{Re}\left[\frac{Z_0 I_0 \beta}{c}\hat{A}e^{j\omega t}\right] = 2c^3\omega u_0(1 + bc)\mathrm{Re}(\hat{A}e^{j\varphi}).$$

Thus we can obtain a motion equation similar to the one in Rowe's book:

$$\begin{aligned}[1 + 2cu(y, \varphi_0)]\frac{\partial u(y, \varphi_0)}{\partial y} &= -(1 + bc)\mathrm{Re}[\hat{A}\cdot e^{j\varphi(y,\varphi_0)}] \\ &+ \frac{1}{4}\left(\frac{\omega_p}{\omega c}\right)^2 \cdot \int_{-\infty}^{\infty}\exp\left\{-\frac{1.25}{\beta_e b'}|\varphi(y,\varphi_0') - \varphi(y,\varphi_0)|\right. \\ &\left.\cdot [1 + 2cu(y, \varphi_0')]\right\}d\varphi_0'\mathrm{sgn}[\varphi(y, \varphi_0) - \varphi(y, \varphi_0')].\end{aligned}$$

Here b' is the electron injection radius, $\beta_e = \omega/u_0$. In general large signal computations we let

$$u_c(y, \varphi_0) = 1 + 2cu(y, \varphi_0).$$

therefore, Eq. (10) can be rewritten as:

$$\frac{\partial u_c(y, \varphi_0)}{\partial y} = [-(1 + bc)\mathrm{Re}(\hat{A}e^{j\varphi}) + F_{sc}]2c/u_c(y, \varphi_0),$$

In which, F_{sc} is the second term on the right hand side of Eq. (10), and is the space charge force term. Regarding u_c on the right hand side of Eq. (12) as a known number, after discretization, we obtain

$$u_{c_{k+1}} = u_{c_k} - [(1 + bc)\mathrm{Re}(\hat{A}_{k+\frac{1}{2}}e^{j\varphi_{k+\frac{1}{2}}}) - F_{sc}]\Delta y 2c/u_{c_k}.$$

In order to be more precise, we adopted

$$u^2_{c_{k+1}} = \{u^2_{c_k} - [(1 + bc)\,\mathrm{Re}(\hat{A}_{k+\frac{1}{2}} e^{j\varphi_{k+\frac{1}{2}}}) - F_{sc}]\Delta y 4c\}^{1/2}.$$

Here, $\hat{A}_{k+\frac{1}{2}}$ represents the field of the midpoint between z_k to z_{k+1}.

The results of computation demonstrate: For the situation $F_{sc} = 0$, Eq. (13) is adopted and the relative error of circuit power and electron injection power is about 2 percent at the time of saturation; and after adopting Eq. (13), the relative error of power was reduced to less than one thousandth which may be accepted as entirely computational error.

Since our velocity reference system was different from Rowe's, we used a natural system, therefore the phase equation changes to:

$$\frac{d\varphi(y,\varphi_0)}{dy} = \frac{1}{c}\cdot\frac{1}{[1 + 2cu(y,\varphi_0)]}.$$

V. Electron Injection Excitation of the Field

Electron injection excitation of the field is primarily computed through the energy conservation relationship. First of all, we found the power which a single charge plate exerted on the field through the region z_k to z_{k+1}. The power exerted by the ith charge plate on the kth step may be expressed:

$$\Delta U_{i,k} = Q_D E_{rf_{i,k}} \cdot \Delta z,$$

in which Q_D is the charge of the charge plate,

$$Q_D = \frac{I_0}{F N_d}$$

Here, N_d is the number of charge plates in each cycle and F is the frequency. Substituting Q_D and E_{rf} in Eq. (16) we get:

$$\frac{\Delta U_{i,k}}{\Delta z} = \frac{I_0}{F N_d}\,\mathrm{Re}\left[\frac{Z_0 I_0 \beta}{c}\,\hat{A}_{k+\frac{1}{2}} e^{j\varphi(y_{k+\frac{1}{2}},\varphi_0)}\right].$$

Integrating all the charge plates in a cycle and dividing it by the cycle we obtain the excitation power which the electron injection gives to z_k to z_{k+}:

$$\frac{\Delta P_{b_k}}{\Delta z} = \frac{I_0}{2\pi}\int_0^{2\pi} \frac{Z_0 I_0 \beta}{c}\,\mathrm{Re}\,[\hat{A}_{k+\frac{1}{2}} e^{j\varphi(y_{k+\frac{1}{2}},\varphi_0)}]\,d\varphi_0.$$

Converting it to normalized coordinate y, we get:

$$\frac{\Delta P_{b_k}}{\Delta y} = 4cI_0V_0\,\frac{1 + bc}{2\pi}\int_0^{2\pi} \mathrm{Re}[\hat{A}_{k+\frac{1}{2}} e^{j\varphi(y_{k+\frac{1}{2}},\varphi_0)}]\,d\varphi_0.$$

Here, it should be noted in particular that the electron field used was the electron field of the midpoint from z_k to z_{k+1}, this and the motion equation used are completely uniform.

The power obtained by the circuit in the z_k and z_{k+1} area is:

$$\begin{aligned}\Delta P_k = I_0V_0\Delta\eta = 2cI_0V_0[(\hat{A}_k + \Delta\hat{A}_k)^2 - |\hat{A}_k|^2]\\ = 4cI_0V_0\mathrm{Re}\left[\left(\hat{A}_k + \frac{\Delta\hat{A}_k}{2}\right)^* \cdot \hat{A}_k\right]\end{aligned}$$

Here, * represents the complex conjugate. Let $\Delta P_k = \Delta P_{bk}$, and assume action in the field $\hat{A}_{k+\frac{1}{2}}$ on electron injection is the average of the inlet and outlet fields, i.e., let

$$\hat{A}_{k+\frac{1}{2}} = \left(\hat{A}_k + \frac{\Delta\hat{A}_k}{2}\right)$$

and

$$\varphi_{k+\frac{1}{2}} = \frac{1}{2}(\varphi_{k+1} + \varphi_k),$$

then we get the equation of the excitation field:

$$\Delta\hat{A}_k = \frac{1+bc}{2\pi}\int_0^{2\pi} e^{-j\varphi(y_{k+\frac{1}{2}},\varphi_0)}\,d\varphi_0\,\Delta y.$$

under normalized conditions, Eq. (1) changes to:

$$\hat{A}_{k+1} = (\hat{A}_k + \Delta\hat{A}_k)e^{-j\left(\frac{1+bc}{c}\right)\Delta y-(1+bc)d\Delta y}.$$

Eqs. (14), (15), (22), (23), (24), and (25) form a complete working equation group. Since these six equations are very simple algebraic equations, they are very easy to solve, and the solutions are very stable. No particular explanation is required for computation of these equations. Here we will only explain simply the next process in the overall solution: under known initial conditions, first from solving the electron motion equations from Eqs. (14) and (15) we find the normalized velocity u_{ck+1} and phase φ_{k+1} (for the first iteration, let $\Delta\hat{A}_k^{(1)}=0$ and $\varphi_{k+1}^{(1)}=\varphi_k$). Then from Eq. (24) find $\Delta\hat{A}_k^{(2)}$, and then use Eqs. (22) and (23) to find a new $\hat{A}_{k+\frac{1}{2}}$ and $\varphi_{k+\frac{1}{2}}$. Then carry out a new iteration, i.e., once again solve the electron motion equation from Eqs. (14) and (15), and compute a new $\Delta A_k^{(3)}$. This is repeated until $|\Delta A_k^{(n+1)} - \Delta A_k^{(n)}| < \varepsilon$, ε is the given error. Since under ordinary conditions $\Delta\hat{A}_k$ is much smaller than A_k, the speed of convergence of this iteration is very fast.

For computation of the space charge field, inlet charge plate distribution is used, but not the charge plate distribution at $z_{k+\frac{1}{2}}$. The computation of the space charge field is unrelated to number of iterations, the iterations only change the high frequency field. This saves a great deal of time, but at the same time can introduce some error. In addition, the suppositions of Eq. (22)

can also introduce error. All these errors not only are related to step length but also are related to degree of excitation, and the stronger the excitation, the greater the error. To reduce these errors, we adopted a method to change the step length.[2] The stronger electron injection bunching, the smaller the step length, generally until saturation is at $\Delta y < 0.02$. With such a small step length, the error introduced by these factors is not very large.

VI. Computation Results

A program using the new model computations has already been set up. Figure 2 gives the changes in power along the axial distance at different cs and bs when $Q_c = 0$ and $d = 0$, and at the same time gives the results using Rowe's model for comparison. The solid line in the illustration is the result using the new model. Since here we did not take into account loss and space charge force, the power flow and the power flow of electron injection loss in the circuit computed using the new model are almost completely equal. As for Rowe's model, between the two there is a certain difference. The dotted line represents the circuit efficiency, N_c:

$$\eta_c = 2c|\hat{A}|^2;$$

and the broken line represents the efficiency obtained from electron injection power consumption,

$$\eta_b = \frac{1}{N_d}\sum_{i=1}^{N_d}[1-(1+2cu_i)^2].$$

For the new model, the difference of N_c and N_b in all computation results is smaller than 0.01 percent, therefore only a curved line could be drawn in the illustrations. For Rowe's model, under all conditions, N_c was always greater than N_b. The results of the new model are also smaller than the N_b of Rowe's model. These are all equal to the anticipated results. These three efficiency differences increase as c increases; and increase as b diminishes. Figure 2(a) and Figure 2(b) are the results when $b = 1$ under different cs, their efficiency difference is small, but Figure 2(c) and Figure 2(d) are the results when $b = 0$, and the corresponding efficiency differences are much greater. Table 1 gives the computational results under saturation to compare more clearly the efficiency errors of the different models under different synchronous conditions. Here, using Rowe's model,

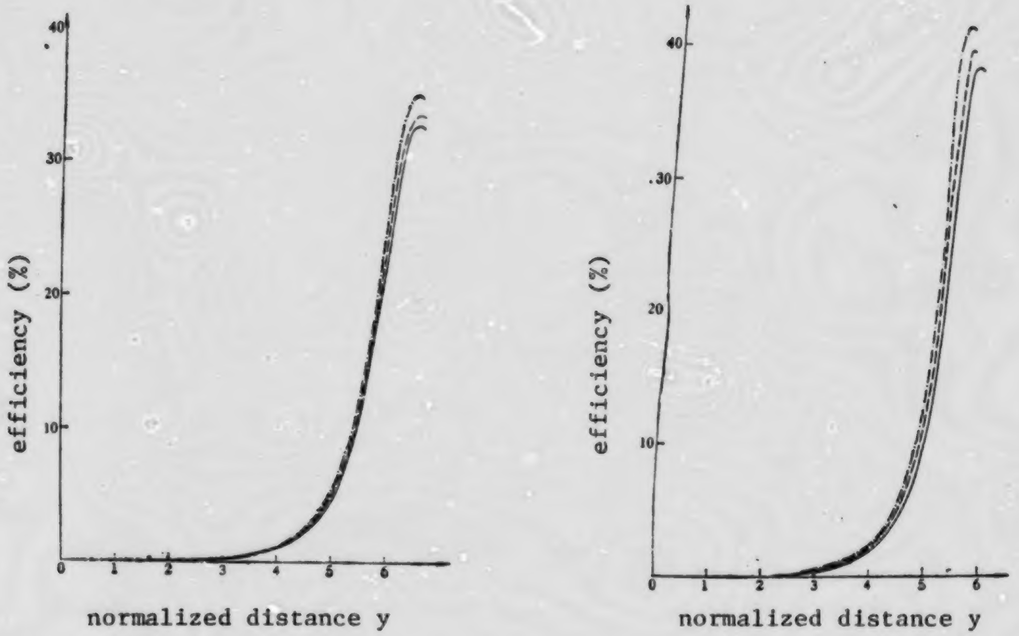
$$\eta_{c,R} = 2cA^2\frac{[1-cd\theta/dy]}{(1+bc)}.$$

If δ_n, is used to represent the relative error of the two efficiencies themselves when Rowe's model is used, then

$$\delta\eta_1 = \frac{\eta_{c,R}-\eta_{b,R}}{\eta_{b,R}};$$

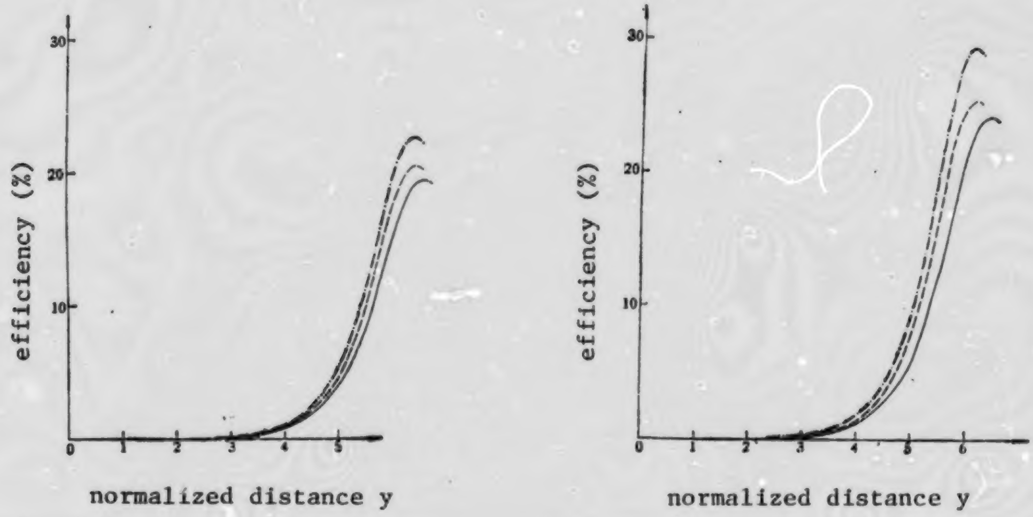
if δ_{n2} is used to represent the relative error between circuit efficiencies under the two models, then

$$\delta\eta_2 = \frac{\eta_{c,R}-\eta_n}{\eta_n}.$$



(a) c = 0.1, b = 1

(b) c = 0.15, b = 1



(c) c = 0.1, b = 0

(d) c = 0.15, b = 0

Figure 2. Relationship of efficiency and normalized distance in two models ($Q_c = 0$, $d = 0$)

-·- circuit efficiency of Rowe's model

--- electron injection efficiency of Rowe's model

—— efficiency with new model (both efficiencies are equal)

Table 1. Efficiencies and Errors of the Two Models

Efficiencies and errors	$c = 0.1$				$c = 0.15$			
	$b = 1$		$b = 0$		$b = 1$		$b = 0$	
	Rowe's model	New model	Rowe's model	New model	Rowe's model	New model	Rowe's model	New model
η_e	36.34	32.75	23.90	19.44	41.20	38.10	32.59	24.30
η_b	33.49	32.75	20.29	19.44	39.30	38.10	25.52	24.30
$\delta\eta_1$	8.51		17.79		4.83		27.70	
$\delta\eta_2$	10.96		22.94		8.13		34.11	

Here, N_n is the efficiency when using the new model in this paper. In this case, the b = 1 group is the situation when close to optimum efficiency; and the b = 0 group represents the work situation when a harmonic current is made to be maximum. When b = 1, the relative difference between the two models is smaller, generally smaller than 10 percent; but for the b = 0 situation, the relative error under the two models is as great as 20 to 30 percent. This also means that an improved interactive model is even more necessary for variable speed computations.

The above computations were carried out under circumstances in which Q_c and d were equal to zero. This was to save computation time, but also it was because under such ideal conditions, it is most easy to check for problems of the interactive model itself. After taking into account the space charge force and loss, the situation also should be the same. In computation of variable speed, we considered all practical factors. Figure 3 is the computation results for variable intercept. The first segment parameters are: c - 0.078, b = 0, $Q_c = 0.15$, $\beta_{\varepsilon b}' = 0.51$, d = 0.05, R = 0.51; parameters after intercept tapering are: c = 0.068, b = 5, $Q_c = 0.25$, $\beta_{\varepsilon b} = 1.0$, d = 0.05, R = 0.59. These parameters were obtained from computation of the helical velocity and impedance of actual TWT. The solid line in Figure 3 represents the changes in efficiency with normalization distance, the dotted line represents the fundamental wave component of the current, and the broken line represents the phase difference between the injection current and the electron field. From Figure 3 it can be seen clearly the process of phase bunching and rebunching of electron injection produced by variable intercept. In the vicinity of the point of gradual change, the changes in the phase difference of the bunching center and the electron field is very fast, and after it reaches the saturation point it enters the area of acceleration, and at the same time, the fundamental wave element of the electron injection current drops sharply, i.e., the electron injection begins to debunch; and after adding variable intercept, the phase difference once again falls into the area of decreasing speed, and the injection's fundamental wave current also no longer decreases, and within one segment after that, it is maintained at a certain level.

Because Rowe's model is a second order partial differential equation, when computing the variable intercept, the influence of boundary conditions is very great, and frequently instability can appear. The new model has overcome this shortcoming, and since the equation is a first order differential equation, boundary conditions are easily given, and under most circumstances, computation results are stable. Discussion of the computation, analysis, and design of variable speed problems and their comparison with the experimental results will not be carried out here due to limitations of space.

VII. Conclusion

The above computation results can show that the new model has many superiorities over Rowe's model. Primarily, it realized conservation of energy, and improved computation precision; when b = 0, the significance of this revision is even greater. Thus, in computation of variable intercept, the new model should have even greater superiority.

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EXPERIMENTAL EXPERT SYSTEM, 'BLOCK,' FOR USE IN CIRCUIT DESIGN

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[Text] Abstract: A practical expert system called "Block" is created for analog circuit design, the goal being to use this research to implement ways and means of high level circuit expert systems. "Block" system only requires the output and input signal demands of the given circuit to complete the block design of the circuit automatically and rapidly while these tasks ordinarily must be done by the circuit designer.

I. Expert Systems and Basic Concepts

The expert system is an important and useful aspect of artificial intelligence. In 1979, A. Simon[1] reported the use of the experimental expert system Bacon-3 in discovering physical laws. In recent years, in China and abroad on the basis of their own needs scholars in various fields have cooperated with computer specialists to explore and develop expert systems which have been used on a trial basis in medical diagnosis, geological exploration, and petroleum engineering. This paper reports the preliminary results of our research on an expert system for circuit design.

Existing computer aided circuit design (CAD) generally demands that the machine be allowed to know the topology and the nature of the elements in the circuit then the machine would adjust and improve the parameters of the elements until the demands were satisfied. That is, selection of the basic structure of the circuit (the topology and the nature of the elements) was carried out by the human brain and not by the machine. An expert system for circuit design should only require the output and input demands (and other additional demands) on the circuit, and on the basis of the specialized knowledge of circuits which the

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system has mastered, it automatically selects the circuit's topology and the nature of the elements and designs a circuit which will satisfy the demands. For this, the following two problems have to be resolved[2]:

(1) How to express knowledge of circuit design, such as circuit laws, the characteristics of active elements and inactive elements, integrated circuit parameters, and methods of synthesizing circuits into a form suitable for the computer to master and structure it into the necessary and complete system, i.e., the problem of creating a knowledge base.

(2) Developing a suitable heuristic procedure so that on the basis of the demands of the problem and the knowledge in the knowledge base the computer will find the answers.

Setting up an expert system which can resolve design questions for different types of complex circuits will be a topic which will take a great deal of work. To explore the ways and means, we first limit the problem to a smaller scope.

Here, the design of analog circuits is expressed as finding a system which can carry out the conversion of one group of input spectral lines into another group of output spectral lines i.e., it can be thought of as a problem of frequency domain so that the computer can process it, and this can be written.

$$[V_1(\omega),\ I_1(\omega)] \xrightarrow{C=?} [V_2(\omega),\ I_2(\omega)],$$

in which

$$V_1(\omega) = \int_{-\infty}^{\infty} v_1(t)e^{-j\omega t}dt, \qquad I_1(\omega) = \int_{-\infty}^{\infty} i_1(t)e^{-j\omega t}dt;$$

$$V_2(\omega) = \int_{-\infty}^{\infty} v_2(t)e^{-j\omega t}dt, \qquad I_2(\omega) = \int_{-\infty}^{\infty} i_2(t)e^{-j\omega t}dt;$$

$v_1(t)$ and $i_1(5)$ are the known signal voltage and signal current of the input terminal of the circuit to be found; $v_2(t)$ and $i_2(5)$ are the known signal voltage and signal current of the output terminal of the circuit to be found; C represents the conversion system needed, i.e., the circuit to be designed.

When $v_1(t)$, $v_2(t)$, $i_1(t)$, and $i_2(t)$ are the cycle functions of time, the corresponding $V_1(w)$, $V_2(w)$, $I_1(w)$, and $I_2(w)$ are discrete and can be expressed as

voltage input = $$[\omega_i^{Iv} \mid V_i^{Iv}] = \left[\begin{array}{c|c} \omega_0^{Iv} & V_0^{Iv} \\ \omega_1^{Iv} & V_1^{Iv} \\ \vdots & \vdots \\ \omega_n^{Iv} & V_n^{Iv} \end{array}\right],$$

voltage output = $$[\omega_i^{Ov} \mid V_i^{Ov}] = \left[\begin{array}{c|c} \omega_0^{Ov} & V_0^{Ov} \\ \omega_1^{Ov} & V_1^{Ov} \\ \vdots & \vdots \\ \omega_m^{Ov} & V_m^{Ov} \end{array}\right],$$

in which $\omega_i^{iv}(i=0,1,\cdots,n)$ is the spectral line of the frequency in the input voltage, $\dot{V}_i^{iv}(i=0,1,\cdots,n)$ is the complex amplitude which the spectral line W_I^{iv} has; $\omega_j^{ov}(j=0,1,\cdots,n)$ is the spectral line of the frequency in the output voltage, V_j^{ov} is the complex amplitude of the spectral line W_j^{ov}.

$$\text{current input} = [\omega_l^{ic} \mid \dot{I}_l^{ic}] = \left[\begin{array}{c|c} \omega_0^{ic} & \dot{I}_0^{ic} \\ \omega_1^{ic} & \dot{I}_1^{ic} \\ \vdots & \vdots \\ \omega_k^{ic} & \dot{I}_k^{ic} \end{array}\right],$$

$$\text{current output} = [\omega_g^{oc} \mid \dot{I}_g^{oc}] = \left[\begin{array}{c|c} \omega_0^{oc} & \dot{I}_0^{oc} \\ \omega_1^{oc} & \dot{I}_1^{oc} \\ \vdots & \vdots \\ \omega_p^{oc} & \dot{I}_p^{oc} \end{array}\right],$$

in which $\omega_l^{ic}(l=0,1,\cdots,k)$ is the spectral line of the frequency in the input current, $\dot{I}_l^{ic}(l=0,1,\cdots,k)$ is the complex amplitude which the spectral line W_L^{1C} has; $\omega_g^{oc}(g=0,1,\cdots,p)$ is the spectral line of the frequency in the output current, $\dot{I}_g^{oc}(g=0,1,\cdots,p)$ is the complex amplitude which the spectral line W_g^{oc} has.

Below we introduce certain basic concepts and symbols to aid the discussion.

(1) Input, output and states

INP--a group expressing the completeness of a system terminal input signal, called input, for short, specific content is as illustrated in Eqs (2) and (4), it also can take other forms;

OUT--a group expressing the completeness of a system terminal input signal, called output, for short, specific content is as illustrated in Eqs (3) and (5), it also can take other form;

S_i--a group expressing the completeness of a signal at an intermediate location i in the system, called 'state' for short. S_1 = INP, is also called initial state.

S_f = OUT is end state.

(2) Differential functions

$D(S_i,S_j)$--used to express the difference of signal in states S_i and $S_j i_e$ of a group completeness;

D(INP,OUT)--used to express the difference of input and output of a group completeness; and

$D(INP,OUT)=D(S_1,S_f)$; $D(S_i,S_j)=0$ indicates that S_i and S_j are the same, i.e., there is no difference.

(3) Goals

The task that must be resolved to make part (one element is zero) or all of the differential function $D(S_i, S_j)$ is zero, is called the goal $G_{i,j}$.

(4) Operators

Operators are the specific techniques of realizing goals. In this paper, it represents a circuit block having a certain function. The operator $R_{i,j}$ makes the signal in state S_1 change to state S_j through its conversion, written $S_i \xrightarrow{R_{i,j}} S_j$, the concatenation relationship in the operator is expressed as a multiplication sign, i.e., $R_{i,j} \cdot R_{j,k} = R_{i,k}$.

(5) Knowledge base

The information gathered is controlled by, computer programs, and is expressed by program decision rules or memory contents. According to this, the machine can find the corresponding operator depending on the goal.

Figures 1 and 2 give two possible forms of the circuit building expert system we are considering. When setting up the "Block" system, we adopted the form in Figure 1.

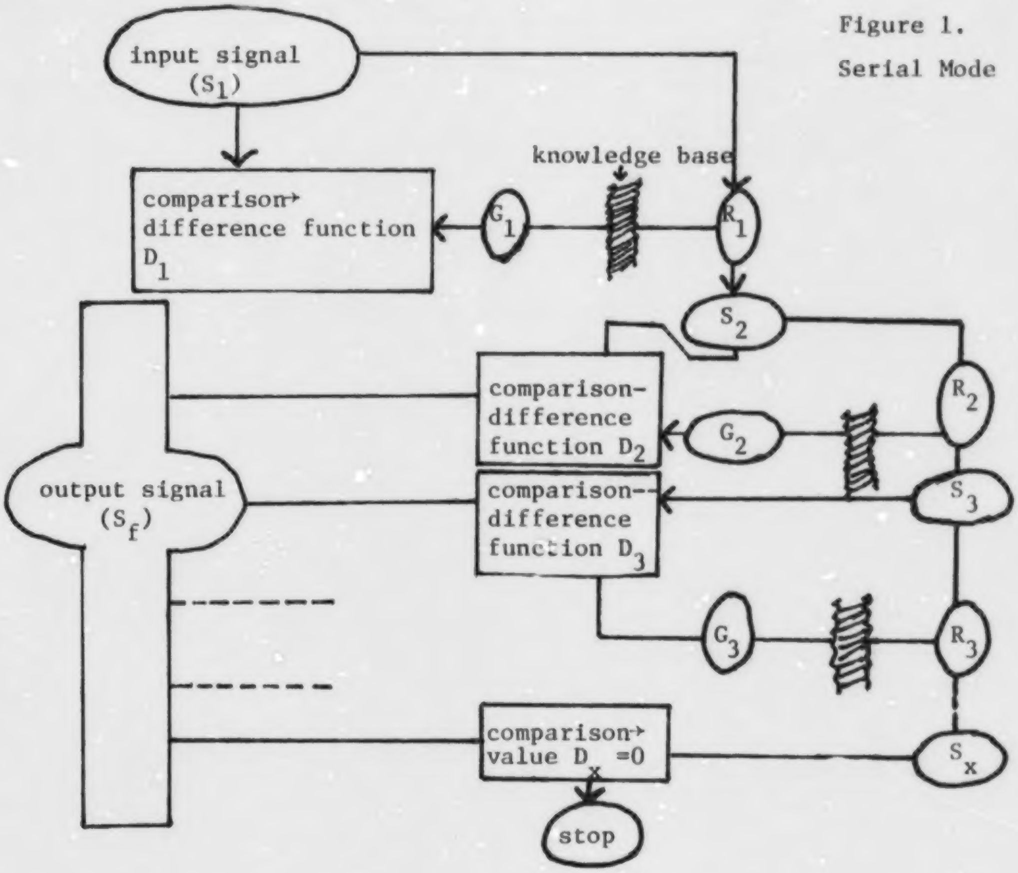

input signal
(S_1)
knowledge base
comparison→
difference function
D_1
G_1
R_1
S_2
comparison-
difference
function D_2
G_2
R_2
output signal
(S_f)
comparison--
difference
function D_3
S_3
G_3
R_3
comparison→
value D_x =0
S_x
stop

Figure 1.
Serial Mode

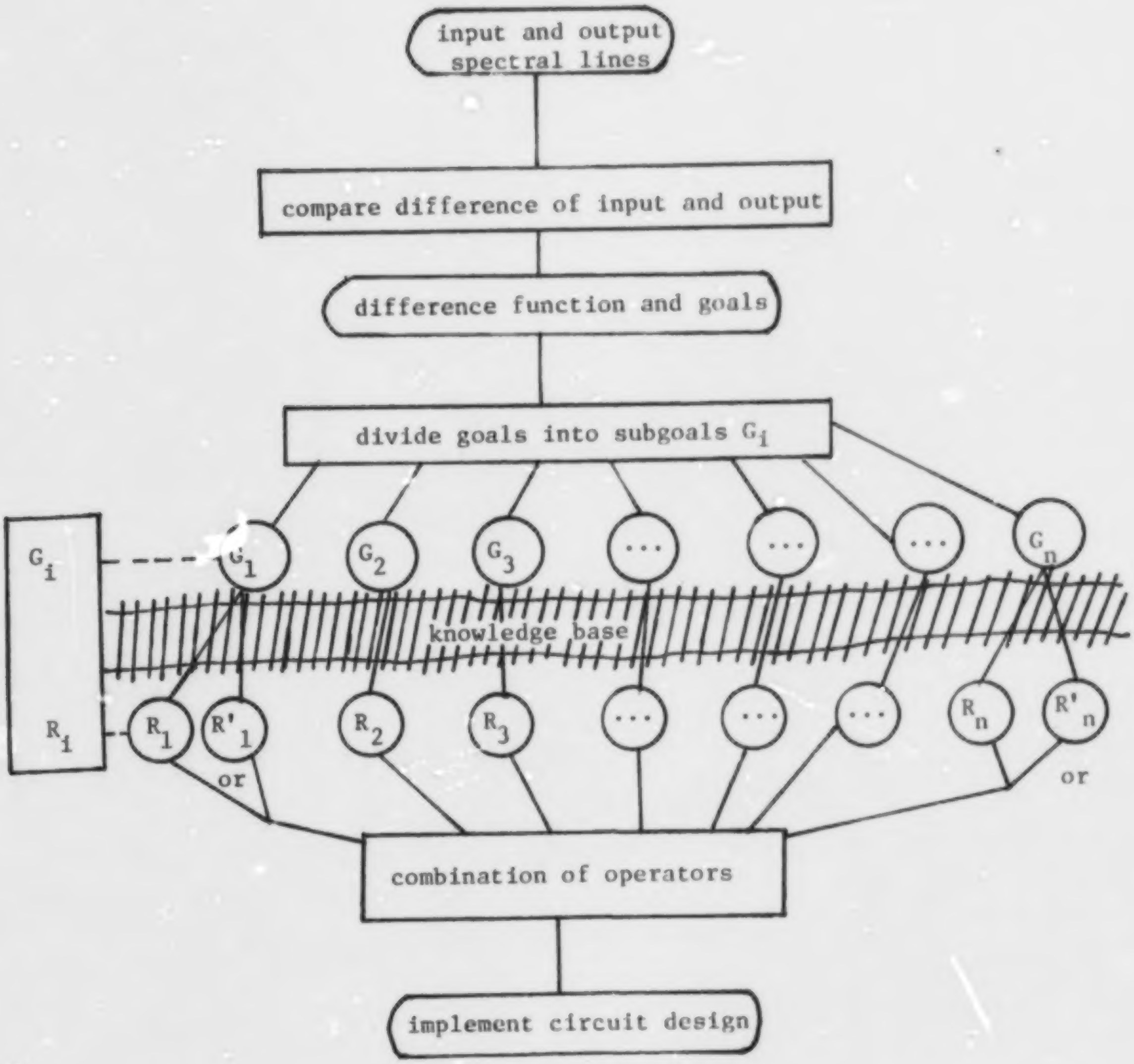

input and output spectral lines
compare difference of input and output
difference function and goals
divide goals into subgoals G_i
G_i
G_1
G_2
G_3
...
G_n
knowledge base
R_i
R_1
R'_1
or
R_2
R_3
R_n
R'_n
or
combination of operators
implement circuit design

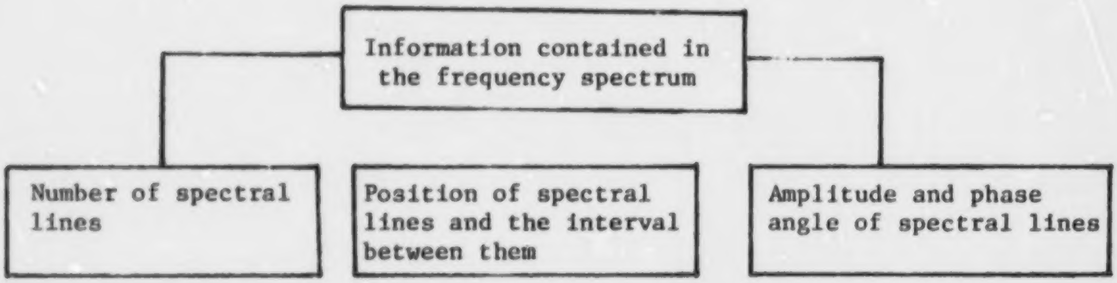
Figure 2. Parallel mode

II. Main Points of the "Block" System

After the "Block" system receives the input spectral group INP and the output spectral group OUT of the circuit to be designed, it carries out a series of comparison on them to find the difference function and determine the goal, and finds the operator to realize the goals through decision. The complete signal used for comparison and decision is the number of spectral lines, the position of spectral lines (i.e., the frequencies) and the intervals between them, and the amplitude and phase angle of each spectral line, as illustrated in Tables 1(a), (b), and (c).

Table 1

(a) Information contained in the frequency spectrum


Information contained in the frequency spectrum
Number of spectral lines
Position of spectral lines and the interval between them
Amplitude and phase angle of spectral lines

(b) Information contained in a single spectral line

Position W_i	Amplitude A_i	Phase angle φ_i

(c) Information contained in spectral group

Position difference $W_{i+1}-W_i$	Amplitude difference $A_{i+1}-A_i$	Phase angle difference $\varphi_{i+1}-\varphi_i$
Relative position difference $\frac{W_{i+1}-W_i}{W_i}$	Relative amplitude difference $\frac{A_{i+1}-A_i}{A_i}$	Relative phase difference $\frac{\varphi_{i+1}-\varphi_i}{\varphi_i}$

Below are the important steps in comparison and decision:

(1) Compare the N_1 and N_0, the number of spectral lines contained in INP and OUT, if $N_1 < N_0$, then invoke the non-linear portion operator ("oscillator" and "mixer") to wait for a command;

(2) Eliminate spectral lines of identical frequency contained in INP and OUT, and if some of the spectral lines in OUT are not eliminated, then invoke the non-linear operator, otherwise, invoke the linear operator ("filter," "amplifier," and "attenuator");

(3) Check to see if there are some spectral lines in INP which have not yet been eliminated, and if there are any, call the operator "filter" to wait for a command;

(4) Compute the amplitude ratio between the spectral lines of identical frequency contained in INP and OUT, and if the amplitude ratio is not a constant, then call the operator "filter" to wait for a command, otherwise compute gain A;

(5) If $A>0$, then call operator "amplifier" to wait for a command, if $A<0$, then call operator "attenuator" to wait for a command, otherwise call operator "short circuit line."

The comparison and decision carried out on the program flow branch will further analyze in detail the content of the operator waiting for a command to determine the specific type and the appropriate parameters. This is omitted here.

In the knowledge base there are also some standard operators, such as standard amplifier 1, standard amplifier 2,... etc. If they should be suited to the demands of the performance parameters required in a problem, then the machine will propose it. In order to simplify matters, the features of the operators have been idealized for the time being, for example, filters do not calculate loss, mixer efficiency is 1, etc.

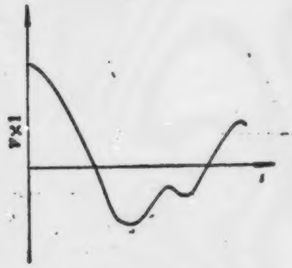
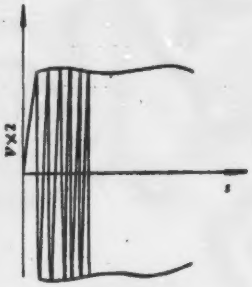
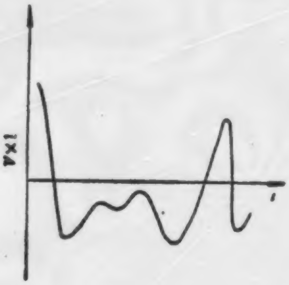
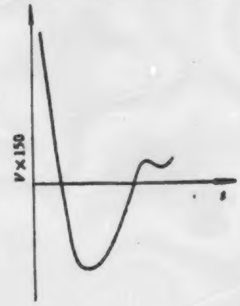
III. Checking Examples and Brief Conclusion

We used a program of about 700 statements in FORTRAN-IV for the above described "Block" system. The system's capabilities are as illustrated in the two conventional assessments in Table 2.

Since the specialized knowledge which can be given to a machine is still very limited, "Block" is only an experimental system, whose primary aim is to clarify some of the problems encountered in constructing an expert system and how to resolve them, and to provide a basic model for further work.

Owing to large-scale application of integrated circuits at present, circuits are becoming more and more modularized. The work of circuit designers need not be meticulous about deciding on single basic components (transistors, resistors, capacitors, and inductors), but to a large degree need only decide on the block diagram and modules of the circuit, especially for digital cir-

Table 2 Assessment Examples

Input circuit designed INP	Output circuit designed OUT	Computer responses to problems
 kHz $[\omega_i \mid V_i] = \left[\begin{array}{c\|c} 50 & 5.0 \\ 60 & 6.0 \\ 80 & 7.0 \\ 100 & 6.0 \\ 110 & 5.0 \end{array}\right]$	 kHz $[\omega_i \mid V_i] = \left[\begin{array}{c\|c} 1130 & 10.0 \\ 1140 & 12.0 \\ 1160 & 14.0 \\ 1180 & 12.0 \\ 1190 & 10.0 \end{array}\right]$	(1) First cut in a mixer, frequency f_c=1080kHz, then connect a filter as described in (2); (2) one bandpass filter, with these characteristics: central frequency f_0 1159kHz bandwidth Δf=86kHz series N=7 (Butterworth model) (3) one amplifier, characteristics: central frequency f_0'= 1160kHz bandwidth $\Delta f_0'$=60kHz gain G=6.02dB This proposal used No. 2 standard amplifier.
 kHz $[\omega_i \mid V_i] = \left[\begin{array}{c\|c} 2005 & 0.1 \\ 3400 & 0.1 \\ 5000 & 0.1 \\ 5100 & 0.1 \\ 5300 & 0.1 \\ 7600 & 0.1 \\ 7800 & 0.1 \end{array}\right]$	 kHz $[\omega_i \mid V_i] = \left[\begin{array}{c\|c} 5000 & 15.0 \\ 5100 & 15.0 \\ 5300 & 15.0 \\ 7600 & 15.0 \\ 7800 & 15.0 \end{array}\right]$	(1) requires only a linear module (2) first cut in high pass filter with the following characteristics: central frequency f_o=6400kHz bandwidth Δf=3000kHz series N=24 (Butterworth model) then connect an amplifier as described in (3) (3) one amplifier with the following characteristics: central frequency F_0'=6400kHz bandwidth $\Delta f'$=2800kHz gain G=43.52dB no standard amplifier can be found.

cuits. On the other hand, the types of integrated blocks is legion, and searching handbooks and data is very time consuming, thus setting up an expert system with a knowledge base of relevant knowledge and data so that the machine will be able to replace man in carrying out some design appears to be very essential. The work of this article shows that it is also completely possible.

The work in this article was carried out by the authors during advanced study at Ohio University in the U.S., and we wish to express our gratitude to the Department of Electrical Engineering at Ohio University for making it possible.

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8226/8918
CSO: 4008/1027

APPLIED SCIENCES

VERTICAL POLARIZED ANTENNA FOR SYNTHETIC APERTURE RADAR

Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 7, No 2, Mar 85 pp 158-160

[Article by Wang Ruxian [3769 3067 6343] and Shen Guanhong [3088 6306 5725], Institute of Electronics, Chinese Academy of Sciences*]

[Text] Abstract: This paper describes a simple design method of a vertical polarized antenna operated in the X-Band. This antenna consists of longitudinal shunt slotted array at the broad side of rectangular waveguide and metallic horned plates. A full size model was fabricated. The computed results are in agreement with measured ones approximately. Although this method is preliminary, it has practical value in antenna design.

I. Introduction

Synthetic aperture radar is imaging radar. It carries out imaging of the plotting region's ground targets. Usually, the radar antenna only radiates horizontal polarized electromagnetic waves, but because of the variety and complexity of the ground target, frequently there is a conversion effect of the polarization of the electromagnetic waves. So that the radar can collect more remote sensing information of ground targets, it is clearly not enough just to make polarized emission and reception. Thus, on the basis of an antenna which radiates horizontal polarized waves, we have developed an antenna which radiates vertical polarized waves and provided a radar prototype for flight test imaging and image comparison.

In designing the vertical polarized antenna we used a waveguide slotted array and a horned structure. Its external shape, dimensions and main electrical performance is basically the same as antennas which radiate horizontal polarized waves. However, the slotted waveguide used by the vertical polarized antenna: it opens a series of longitudinal off-axis shift slots on the broad side of a rectangular waveguide to radiate vertical polarized electromagnetic waves.

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*Received 26 Mar 1984, finalized 25 Jul 1984.

II. Vertical Polarized Waveguide Slotted Array

The conductance of the harmonic slots can be computed using the formula[1]

$$G = G_0 \sin^2\left(\frac{\pi x}{a}\right).$$

In the Eq.: $G_0 = 2.09\,\frac{\lambda_g}{\lambda}\left(\frac{a}{b}\right)\cos^2\left(\frac{\pi\lambda}{2\lambda_g}\right)$, λ is the free space wave length, λ_g is the waveguide wave length, a is the waveguide wide side dimensions, b is the waveguide narrow side dimensions; x is the distance between the slotted center line and the waveguide axis line.

For a traveling wave type array, the reflection coefficient ρ of the input can be computed using the formula[2]

$$\rho = \frac{-\sum_{n=1}^{N}\frac{1}{2}G_n e^{-j\alpha_g 2nd}}{1+\sum_{n=1}^{N}\frac{1}{2}G_n}$$

In the Eq. $\alpha_g = 2\pi/\lambda_g$, N is the number of slots, d is the spacing of adjacent slots, G_n is the conductance of the nth slot in the array.

When frequency changes are not great, one can tell that ρ is only related to $2a_B nd$. When $d = n_g/2$, ρ is at its greatest, it is necessary to avoid making d equal to $n_g/2$. We took $d = 0.53n_g$. Changing the direction of adjacent slot spacing wave guide axial lines one can obtain a 180° phase difference.

The efficiency of the traveling wave array has the following relationship with the normalized conductance[3]:

$$\frac{G_i}{Y_0} = \frac{P_{ri}}{\frac{1}{\eta}\sum_{i=1}^{N}P_{ri} - \sum_{j=1}^{i}P_{rj}}.$$

in which, G_i/Y_0 is the normalized conductance of the ith slot. η is the radiation efficiency of the slotted array, P_{ri} is the normalized radiation power of the ith slot.

The maximum normalized conductance that we actually selected was $G/Y_0 = 0.1$, the slotted array opening face was designed for equal magnitude distribution, the following equation can be used to compute its H-plane directional map[2]:

$$E(\theta) = \frac{\sin\left[\frac{N}{2}\left(\frac{2\pi}{\lambda}d\sin\theta - \frac{2\pi}{\lambda_g}d + \pi\right)\right]}{\sin\left[\frac{1}{2}\left(\frac{2\pi}{\lambda}d\sin\theta - \frac{2\pi}{\lambda_g}d + \pi\right)\right]}.$$

III. E-plane Directional Map

The field distribution on the E-plane of the vertical polarized antenna can be seen to be similar to the electrical field distribution on the E-plane's fan-shaped horned aperture face. Thus, the computational formula for the E face fan-shaped horned E-plane directional map can be used to compute approximately the E-plane directional map of the vertical polarized waveguide slotted array horned antenna.

The equation for the E-plane directional map of a known E-face fan-shaped horn is[2]:

$$E(\theta) = -i\,\frac{E_0 b'' a''}{4\sqrt{2n_1}\,\lambda R}\left(\cos\theta + \frac{W}{W_0}\right)e^{-ikR-i\frac{(kb''\sin\theta)^2}{16n_1}}$$
$$\cdot\left\{\left[C\left(\sqrt{2n_1} - \frac{u}{\pi\sqrt{2n_1}}\right) + C\left(\sqrt{2n_1} + \frac{u}{\sqrt{2n_1}}\right)\right]\right.$$
$$\left. + i\left[S\left(\sqrt{2n_1} - \frac{u}{\pi\sqrt{2n_1}}\right) + S\left(\sqrt{2n_1} + \frac{u}{\pi\sqrt{2n_1}}\right)\right]\right\}.$$

in which θ is the angle of direction; a" is the dimension on the horn aperture face parallel to the direction of the magnetic field; b" is the dimension on the horn aperture face parallel to the direction of the electrical field; E_0 is the electrical field strength in the center of the aperture face; R is the distance of the antenna phase center to the observation point; W_0 is the free space wave impedance; W is the wave impedance in the dielectric; C(Z) and S(Z) are Fresnel's integrals,

$$C(Z) = \int_0^Z \cos\left(\frac{\pi x^2}{2}\right)dx,\quad S(Z) = \int_0^Z \sin\left(\frac{\pi x^2}{2}\right)dx;$$

R' is the horn length; $n_1 = b''^2/4\lambda_g R'$; $u = (\Pi/\lambda)b'' \sin\theta$; $\varphi_z = \Pi b''^2/4\lambda_g R'$.

The antenna gain g can be approximated using the formula

$$g = \frac{4100}{\theta_E\theta_H}\eta_s\eta_{Eh}$$

In the formula θ_E and θ_H are the 3dB beam width (°) of the E-plane and H-plane directional maps respectively, η_s is the slot waveguide array's radiation efficiency (%), η_{Eh} is the E-face fan-shaped horn's aperture face utilization coefficient (%).

IV. Comparison of Computed and Measured Results

1. Computed results: The results of the design computations using the above described method are: we used a rectangular brass waveguide, walls of 1mm thickness, cross section area of 23 x 10mm^2; 62 longitudinal slots 16mm long and 1.59mm wide were cut in the wide side of the waveguide, distance between adjacent slots was 23.67mm, the maximum distance of the slot offset from the waveguide axis was 2.11mm; the E-plane aperture opening angle was 34°, the

aperture face width was 155mm, aperture face length was 1500mm, E-plane 3dB beam width was 11.2°, H-plane 3dB beam width was 1.1°. If the aperture face utilization coefficient of the waveguide slotted array horn is taken as 0.66, then the gain is estimated at 32dB, computed value of the center frequency's voltage drive wave ratio is 1.18, the efficiency of the waveguide slotted array is 86 percent.

2. Measured Results: The voltage drive wave ratio of the waveguide slotted array in the usage frequency band is less than 1.15, efficiency is 85 percent, the gain is 31.5dB, the beam directional load deflection angle is 2.4; H-plane 3dB beam width is 1.2°, its directional map is illustrated in Figure 1. The E-plane 3dB beam width is 10.8°, its directional map is illustrated in Figure 2.

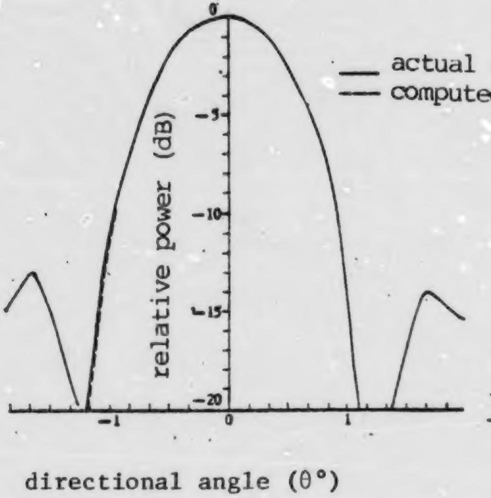

Figure 1. H-plane directional map

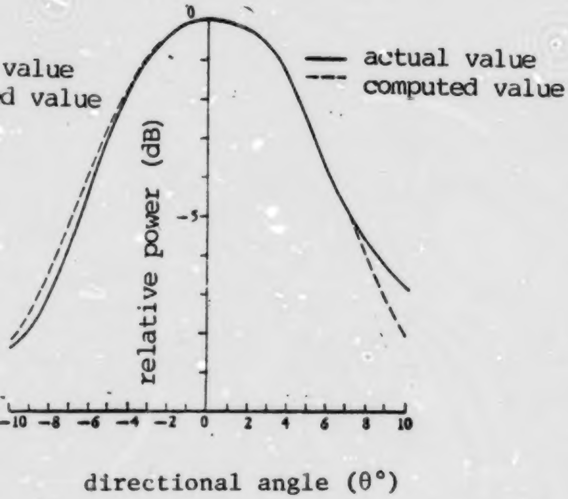

Figure 2. E-plane directional map

V. Conclusion

A narrow face waveguide inclined slotted array horned antenna has already been applied widely, but a horned antenna array which radiates vertical polarized waves is still little used. We developed an experimental antenna according to the method described in this paper. Its conductance distribution was designed according to the measured conductance curve. Radar flight tests demonstrate that this antenna basically satisfies use demands. From this it can be seen that although the design method described in this paper is simple and crude, it has definite practical value.

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APPLIED SCIENCES

CY SERIES INTEGRATED PRESSURE TRANSDUCER

Beijing DIANZI KEXUE JISHU [ELECTRONIC SCIENCE AND TECHNOLOGY] in Chinese
No 12, 10 Dec 84 pp 25-26, 28

[Article by Bao Minhang [7637 2404 2635] and Jiang Jishen [5592 4949 3947]]

[Text] The CY series integrated pressure transducer is a brand-new third generation semiconductor pressure-sensing element whose primary performance indicators have reached or surpassed the advanced levels for similar products abroad.

In order to make the transducer have ideal performance parameters, the CY series pressure transducer integrates on one chip a pressure sensitive bridge, signal amplification circuit, and temperature compensation circuit.

Since silicon material <100> crystal orientation has a mature etching process and at the same time is more ideal for integrated circuit process, therefore P-type <100> crystal orientation silicon chips were chosen for the CY_series products, and pressure-sensitive resistance lines follow <011> and <011> crystal orientation.

A typical circuit of a CY series integrated pressure transducer is illustrated in Figure 1.

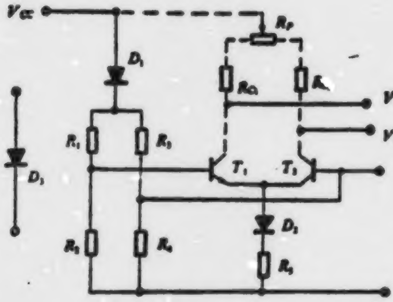

Figure 1. Typical circuitry of integrated pressure transducer

R_1-R_4 is the pressure sensitive resistance bridge, connected as a Wheatstone bridge. The circuitry of this method of connection is simple and has a high degree of precision and sensitivity. When the externally applied pressure is zero, $R_1 = R_2 = R_3 = R_4 = R$, and the bridge output $V_0 = 0$. When the externally applied pressure is P, $\Delta R_1 = \Delta R_4 = -\Delta R_2 = -\Delta R_3 = \Delta R$, and at this time the bridge output

$$V_0 = KP(V_{cc} - V_{be}) \qquad (1)$$

in which K is a constant, P is the externally applied pressure, V_{be} is the forward voltage drop of diode D_1.

The amplification part uses a differential amplification circuit. The signal is input from the bases of two differential transistors T_1 and T_2, and the output is the difference in voltage of the collectors of the two transistors.

The voltage of the entire circuit's output signal is

$$V_{out} = (V_{cc} - V_{be})(V_{cc} - 5V_{be})KP \cdot \frac{q}{K_0 T} \cdot \frac{R_c}{4R_e} \qquad (2)$$

The pressure response curve drawn according to formula (2) is illustrated in Figure 2.

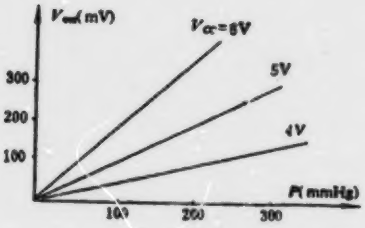

Figure 2. Pressure response curve at different power source voltages

Relationship between of the transducer sensitivity temperature coefficient (TCS) and the power source voltage can be derived by differential calculation by formula (2) and the curve is illustrated in Figure 3.

From Figure 3 it can be seen that when $V_{cc} = 5V$, the TCS of the circuit can be compensated to zero.

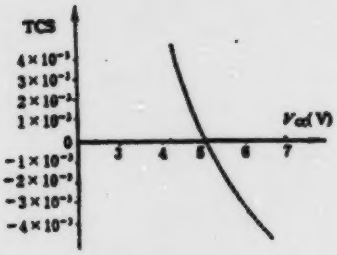

Figure 3. Relationship of sensitivity temperature coefficient and power source voltage

The chip temperature signal which the diode D_3 supplies to the external circuit induces a change of approximately 1.8 mV per degree, and through an external compensatory circuit can compensate for the transducer's zero temperature drift.

Below we discuss the important characteristics of the transducer.

1. Sensitivity

Sensitivity $S = V_{out}/P$, and from formula (2) it can be seen that the magnitude of S is roughly in direct proportion with V_{cc}^2. As V_{cc} increases, S also clearly increases, but considering the influence of temperature characteristics, when V_{cc} = 5V, S = 1000 μV/mmHg, see Figure 4.

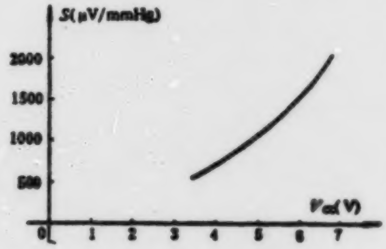

Figure 4. Relationship of sensitivity and voltage supplied

2. Precision and frequency response characteristics

Many users are accustomed to using precision δ to measure the performance of a transducer. The precision indicators are the three root-mean-squares of linearity δ_1, lag δ_2 and repetitivity δ_3

$$\delta = \sqrt{\delta_1^2 + \delta_2^2 + \delta_3^2}\,.$$

Linearity is the difference between the calibration curve of the measured input/output and its theoretical fitting line. The linearity of the integrated pressure transducer is very good and has an error better than 0.5 percent of its magnitude.

The lag expresses the degree to which the input/output curve of the transducer in the forward and reverse position is not uniform. The repetitivity expresses the degree to which the characteristic curve of the transducer obtained when the input quantity changes many times in succession in overall magnitude in the same direction is not uniform. Since the error of lag and repetition of the chip itself is very small, the error is mainly caused by packaging. The CY series products use soft packaging so that packaging stress is reduced, and after aging technology was adopted, the lag and repetitivity both were smaller than 0.5 percent. Thus,

$$\begin{aligned}\delta &= \sqrt{\delta_1^2 + \delta_2^2 + \delta_3^2} \\ &= \sqrt{(0.5\%)^2 + (0.5\%)^2 + (0.5\%)^2} \\ &= 0.87\%\end{aligned}$$

and after grading, the optimum is less than 0.2 percent.

If what is being measured is non-corrosive gas or liquid under constant temperature, it is not necessary to use pressure transmission medium, but the substance to be measured can come in direct contact with the silicon ring. At this time, the precision of the transducer can reach better than 2 parts per 10,000, and frequency response can be better than 20 kHz.

3. Temperature characteristics

Temperature characteristics refers to the two parameters of sensitivity temperature drift and zero point temperature drift. From Figure 1 it can be seen that the characteristic that the forward voltage drop of diodes D_1, and D_2 and the forward voltage drop of junction be of T_1, and T_2 rises and falls with the temperature can be used to raise the voltage of the actual power supplied by the bridge and the working current of the difference transistors, compensating for the resistance sensitivity and the influence of the triode transconductance rising and falling with the temperature. When the power supply voltage is high, the compensating function of the diode is not enough and the entire circuit carries a negative temperature coefficient; when the power supply voltage is low, the compensating function of the diode is too strong and the entire circuit carries a positive temperature coefficient. We have assumed that when $V_{cc} = 5V$, $TCS < 1 \times 10^{-4}/°C$.

To control the zero point temperature drift, we used D3 to access a chip temperature signal, and compensated for the zero point temperature drift through an external compensating circuit so that the zero point temperature drift control is within 0.2 percent.

4. Power consumption and imbalance

In Figure 1, the current across the bridge $I_0 = (V_{cc} - V_{be})/R$, the difference transistor total current $I_c = (V_{cc} - 5V_{be})/2R_5$, total power consumption current $I = I_0 + I_e$. It is already known that $R_1 = R_2 = R_3 = R_4 = R = 2.5\text{k}\Omega$, $R_5 = 6\text{k}\Omega$, $V_{be} = 0.6\text{V}$, the power consumption curve measured is illustrated in Figure 5.

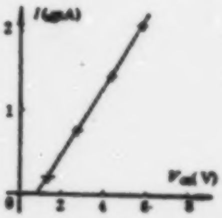

Figure 5. Relationship of power consumption current and supplied voltage

The transducer's offset voltage comes mainly from the asymmetry of the bridge resistance. If a bridge resistance deviates from the balanced ΔR, i.e., $R_1 = R - \Delta R$, $R_2 = R_3 = R_4 = R$, then the resulting bridge output offset voltage is

$$V_{os} = \left(\frac{R}{2R-\Delta R} - \frac{R}{2R}\right)(V_{cc} - V_{be})$$

$$\approx \frac{\Delta R}{4R}(V_{cc} - V_{be})$$

and when $\Delta R/R = 0.5$ percent and $V_{cc} = 5\text{V}$, $V_{os} = 5.5\text{mV}$.

Summarizing the above, compared with other pressure transducers, the CY series products have the following advantages:

1. They have very high sensitivity and ability to resist interference. Full magnitude output is several hundred mV, output sensitivity reaches 1000μV/mmHg, 40-times more sensitive than ordinary solid pressure resistance or tensed wire transducers.

2. They have high measurement precision.

3. They have very good temperature stability.

4. It is miniaturized: the chip measures 2.4 x 2.4 mm, and the diameter of the packaged transducer is ϕ10 mm.

5. The demands on back signal circuit are simplified.

6. They are low in cost.

The applications are briefly discussed below.

1. Biological pressure gauge

The CY-1 is a biological pressure transducer. Attached to a PTM-1 gauge it can measure pressure in the circulatory system of the human body and cranial, esophageal, cervical, and bladder pressure. It is easy to use in clinical diagnosis and is stable in performance. Comparing the primary technical characteristics of the CY-1 biological pressure transducer with the U.S. Gould Company's P-23 biological pressure transducer, in 11 primary technical parameters, it is largely superior to the P-23, as is shown in the table.

Technical characteristic	CY-1	P-23
Magnitude of pressure	-50 ~ +300mmHg	-50 ~ +300mmHg
Sensitivity (5V DC power)	1000μV/mmHg	25μV/mmHg
Sensitivity temperature coefficient	1×10^{-4}/°C	2.7×10^{-4}/°C
Linearity	0.5%	0.5%
Delay	0.5%	0.5%
Bridge resistance	2500Ω	350Ω
Zero point temperature coefficient	2×10^{-3}F.S./°C	0.7×10^{-3}F.S./°C
Weight (not including leads)	9g	45g
Length (main body)	30mm	56mm
Diameter	13mm	18mm
Frequency response characteristics	≈240Hz	≈200Hz

2. Medical pulse gauge

Attaching a simple impedance matching circuit behind the CY-2 transducer and connecting it to an electrocardiogram or recorder makes it possible to measure a pulse and dynamic pulse pressure. It can stimulate the traditional pulse-taking methods of Chinese medicine and output the characteristics of 28 human body pulses.

3. Differential pressure flow gauge

Using the CY-3 differential pressure transducer and restrictor devices it is possible to create a differential pressure flow gauge, which can measure the volume of flow of various liquids. It has the advantages of simplicity, reliability and high degree of precision.

4. Micropressure gauge

Using a CY-4 micropressure transducer, one can measure pressure within the 0~100 mmH_2O range, providing a modernized measuring technique for micropressure measurements in scientific research.

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APPLIED SCIENCES

NEW DT^2L SYSTEM OF LARGE-SCALE INTEGRATED CIRCUIT DESCRIBED

Beijing DIANZI KEXUE JISHU [ELECTRONIC SCIENCE AND TECHNOLOGY] in Chinese No 12, 10 Dec 84 pp 8-11, 18

[Article by Li Yanhong [2621 1750 7703]]

[Text] This article presents a simplified gate circuit and trigger based on existing TTL circuits to create a new series. It is not only suited to China's existing technological level and package cooling technology, but also improves integration and speed and provides experimental proposals for developing China's own medium and large scale integrated circuit series.

New Simplified Gate Circuits

1. NAND Gate

The simplified NAND gates which are popular in China and abroad at present are illustrated in Figure 1. Of the circuits in Figure 1, (a) has the fewest components, but its ability to resist forward interference is very weak and thus it is suited only for internal integrated circuits. The others can be used as input buffer circuits, but each has its shortcomings: although there are few components in (b), the output low level is high and does not match with the built-in low level circuit; (c) has a high low level output and there are also more components; although (d) has good performance, it has too many components which will not improve integration.

Can an input circuit be found which can both maintain the noise immunity level of the TTL and also reduce the number of components? This is the new simplified NAND gate presented in this paper and it is illustrated in Figure 2.

From the structure of the circuit illustrated in Figure 2(a) and (a'), one can see that this is the circuit illustrated in Figure 1(a) with the addition of one diode D and one triode T_2, it is shown open in Figure 2(a), compared to the circuit in Figure 1(a) the input open gate level improves one junction voltage drop. When the circuit returns from saturation to cut-off state, as illustrated in Figure 2(a'), the current turns into gate current through the R_g base and flows out from the T_1 emitter. The load stored in T_3 base region is drawn out by T_1 and T_2. The key here is that T_2 is different from T_1. When the input jumps from high level to low level, the base no longer injects current. It can maintain the reverse current channel because the load stored by bc junction of T2 makes the be junction open so that T2 conducts and reverses the load stored in T3 base, and once the load stored in the T2 base area has been expended, T2 cuts out, and if the load in T3 has been all reversed before T2 cuts out, it accelerates the closing process of T3.

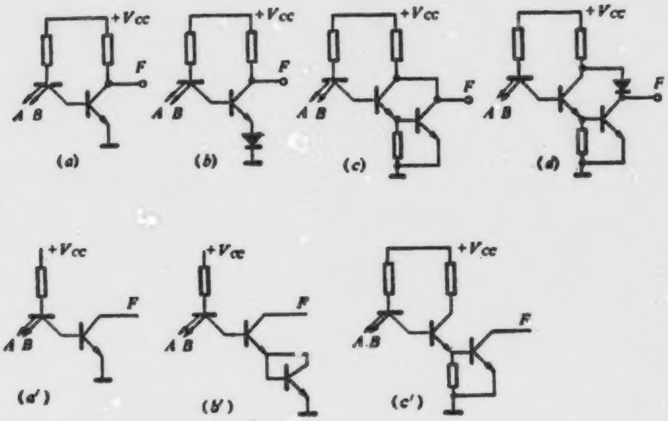

Figure 1. Commonly used simplified NAND gate circuits

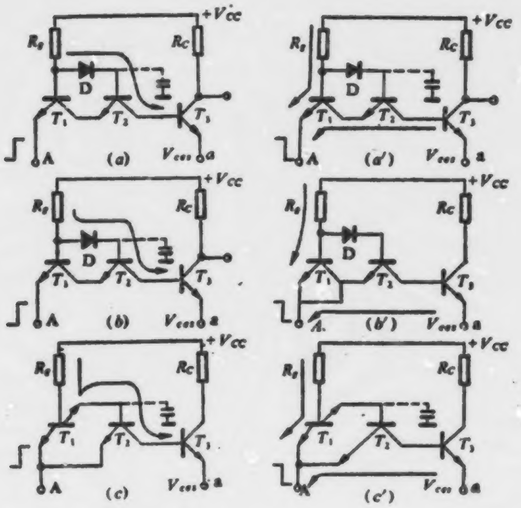

Figure 2. Structural forms of new simplified NAND gates

To further clarify the conducting principles of T_2, we will analyze the charging and discharging process of the two capacitors T_2. Figure 3(a) illustrates the charging process of the bc junction capacitor when the T_2 base is driving. The p and n semiconductors on both sides of the pn junction may be equivalent to the two plates of a capacitor, and the space-charge layer between the pn junction (the part in AB or ab) is equivalent to the dielectric between the plates.

When a high level input, the current flows into the T_2 base from outside through R_g and D, so that the base area is charged, but be junction has not yet conducted it. At this time, the capacitor C_{bc} is charged. It is implemented though changes in the thickness of the space-charged layer, that is, the hole in the p area enters the A side of the space-charged layer, and the electrons in the n area enter the B side of the space-charged layer, thus making the thickness of the space-charged layer smaller and the charge is collected on the reduced area. The charge of the current is illustrated in the figure. When the current charged is sufficient, it makes T_2 enter an amplified state of reverse use, and this amplified current is good for driving the base of T_3.

At the moment that the input changes from high level to low level, as when the input changes from 3.6V to nearly 1.4V, the be junction of T_2 goes from reverse biased to nearly zero biased, and the charge current at this time is supplied by the current through R_g and D. As T_1 conducts, the charged current becomes smaller. And when the input is as small as 1.4V, the charge current of the be junction capacitance of T_2 can no longer be supplied by the power source, but the capacitance of the bc junction is mainly replaced by diffusion capacity releasing the charge accumulated when it was conducting forward. At this time C_{bc} discharges, and at the same time the junction capacitance C_{be} of junction be discharges, i.e., the hole stored in bc junction enters the b side of the be junction's space-charged layer, and the electrons enter the a side, thus the thickness of the space-charged layer becomes smaller, changing from ab to a'b', i.e., the be junction conducts. When this conducting current is sufficient it puts T_2 into the forward amplification state, and at this time, the thickness of the bc junction's space-charged layer becomes greater, changing from AB to A'B', and the bc junction is in the reverse state. Conducting T_2 reverses the T_3 base area charge.

To observe the influence of the stored charge of the bc junction of T_2 on reversing the stored charge of T_3, we carried out an experiment on the circuit illustrated in Figure 4(a). The T_2 in this circuit was a f_T>200 MHz fast transistor, the output waveform is illustrated in Figure 4(b). The experiment showed that when T_2 is a high speed transistor, the capacitance of the collector junction is small and the base area storage charge is not sufficient, reversing the T_3 charge is not an advantage, because the output waveform declines before it has peaked. If a capacitor or diode is added to the bc junction of T_2 or if T_2 is changed to a low f_T transistor, such as 3DKA, then the output waveform is normal, as illustrated in Figure 4(c). Clearly, it demands that the capacity of the bc junction be small, and thus when the domain is designed, this problem should be taken into consideration, i.e., it should be designed with multiemitter transistors and make the f_T a little lower.

- a. T_2 transistor base driven
- b. T_2 transistor base not driven
- c. C_{bc} charge current
- d. C_{bc} discharge current

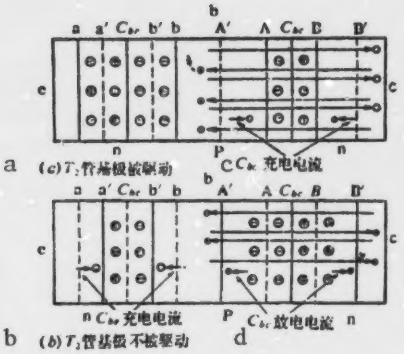
b
a a′ C_{bc} b′ b
A′ A C_{bc} B B′
c
c
n
P
n
a
(a) T_2管基极被驱动
c C_{bc} 充电电流
b
a a′ C_{bc} b′ b
A′ A C_{bc} B B′
c
c
n C_{bc} 充电电流
P C_{bc} 放电电流 n
b
(b) T_2管基极不被驱动
d

Figure 3

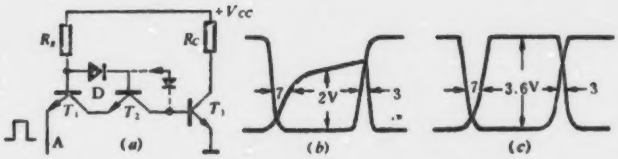
+Vcc
R_s
R_c
D
T_1
T_2
T_3
A
(a)
7
2V
3
(b)
7
3.6V
3
(c)

Figure 4

Table 1

V_A(V)	T_{1b}(V)	T_{1c}(V)	T_{2b}(V)	T_{2c}(V)	T_{3c}(V)
4	2.2	1.56	1.47	0.8	0.2
2	2.2	1.56	1.47	0.8	0.2
1.5	2.2	1.50	1.42	0.8	0.2
1.4	2.2	1.50	1.42	0.8	0.2
1.3	2.0	1.35	1.30	0.76	3.4
1.1	1.84	1.18	1.18	0.67	4.8
0.8	1.56	0.85	0.81	0.4	4.9
0.6	1.30	0.65	0.05	0.2	4.9
0.3	1.18	0.4	0.4	0	4.9

Now we will discuss the function of the diode D. Initially, the aim of adding the T_2 was to improve ability to resist interference, and the introduction of D ensured improvement of the ability to resist interference when compensating for a voltage drop from increasing the input terminals by one junction. D plays a capacitance role at the instant that the input changes from high level to low level. At this time, D changes from forward biased to reverse biased. From the polarity of the junction capacitance one knows that in the process of going from forward biased to reverse biased it can draw off part of the charge stored in the T_2 base area, and can also draw off a small part of the stored charge of T_3. For the charge of the T_2 base area to leak in the D circuit is not an ideal situation, thus in design, we did our utmost to make the capacitance of D smaller so that its stored charge would be small, the reverse biased state could be rapidly restored and stop the reverse action.

To discuss the performance of this circuit in more detail, below we have plotted the necessary test data. The electrical potential of the experimental circuit illustrated in Figure 5 at various parameters are given in Table 1.

From the table it can be seen that at a static open gate level of 1.4V, which shows static anti-interference performance.

The waveform in Figure 6 shows the time characteristics when $R_g = 3K\Omega$, $R_c = 0.4k\Omega$, and when T_2 is a 3DKA.

In addition, we carried out experiments on dynamic anti-interference and time delay characteristics with different combinations of parameters. The results show that performance is very good. With different parameters, the increase time was (5-7)ns but the decrease time was (3-5)ns. Under ordinary conditions, the increase time is 7ns, and the decrease time, 5ns. Compared with the simplified circuit in Figure 1(a), under the same parameters, the time characteristics are all the same, which means that there are advantages to adding T_2.

The structure given in Figure 2(b) and (b') further improves the reverse ability of the T_3 stored charge. It can be seen that at this time, the collector of T_1 doesn't have much importance, thus the actual structure which was further simplified and adopted is the one in Figure 2(c) and (c'). Here we got rid of the connection of the T_1 collector and connected the T_2 emitters directly to the T_1 emitters, and replaced one *be* junction of T_1 with diode D, to fully ensure that the anti-interference input demands would be realized.

Now, a new simplified NAND gate has been produced. Since T_1 essentially functions as a diode, "AND" logic is carried out by a "diode", therefore it was termed a DT^2L circuit. The first "T" refers to T_2, thus distinguishing it from the DTL and TTL series.

The DT^2L element circuit together with other element circuits can form a new circuit system, which demonstrates that it is very flexible in its logic applications. In order to simplify it, here we will cite as an example only an exclusive OR gate and AND-OR-NOT gate circuits which use it. Figure 7 illustrates an exclusive OR gate, with logic form $F = \overline{\underline{a\bar{b}} + \underline{\bar{a}b}}$ and Figure 8 illustrates the AND-OR-NOT gate, with logic form $F = \overline{\underline{ab} + \underline{cd}}$.

Summarizing the above, this new element circuit has the following characteristics: 1. Powerful ability to resist interference (1.4V), 2. high speed (can reach 5ns), 3. high integration (there are only 4-5 simple gate components), 4. low power consumption (1-2 energy consumption resistance), 5. powerful logic application flexibility (may form a series of circuits).

2. AND Gate

Common AND gates are illustrated in Figure 9. They all exist as independent output units. When they are used in LSI circuits, clearly there is a multiplicity of components which demands simplification. We can imagine implementing the "AND" logic part of a circuit in a standard TTL NAND gate, and have extracted it as illustrated in Figure 10(a). It is an input gate. It can be seen that this is a most simplified AND gate.

This circuit not only can be used in an LSI circuit to carry out the AND gate functions, but also has an extremely high transmission speed. Figure 10 also provides the waveform displayed on a high speed oscilloscope. It can be seen that the effective part of the output overlaps the input waveform, requiring almost no transmission time and this is very encouraging.

The reason this circuit has such a fast transmission speed is because on the margin there is capacitance jump partial pressure. The magnitude of the jump is determined by the ratio of C_1 and C_2 (C_1 is the distribution capacitance between the collector and the emitter and C_2 is the output capacitance). If $C_1>C_2$, then the magnitude is large and may be close to the value of E; otherwise, it is small. If C_1 is large, the area of the transistor is large and when the integrated circuit chip is designed, it is handled according to the multiemitter transistor core.

In experiments we measured the magnitude of the jump as 2.6V, dropping 0.1V each time it went through a transistor up to 11 levels (open gate level of 1.4V) consecutively, but actually it could only be transmitted up to 6 levels, primarily because there was some loss of power (including resistance) in transmission from level to level, so it was impossible to create ideal conditions for the capacitance jump partial pressure. Nevertheless, the characteristics of this transmission are useful. In addition, since consecutive transmissions make the low level accumulate, at a certain point it will cause an error, and thus in actual use at the appropriate level the low level should be restored and some of the overall flow to the signal source should be split. This phenomenon is not encountered often, but it should be noted in the design of high-speed carry link circuits.

This characteristic of high speed transmission of high level not only exists in the above described AND gate, but also exists in the exclusive-OR gate in Figure 7, and therefore also exists in the DT^2L circuit series, thus in the logic design of functional blocks, the advantages of this circuit should be exploited as much as possible so as to achieve a higher speed.

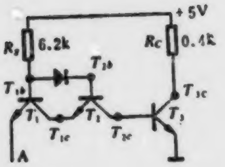
+5V
R_s
6.2k
R_C
0.4k
T_{2b}
T_{1b}
T_{3c}
T_1
T_2
T_3
T_{1c}
T_{2c}
A

Figure 5.

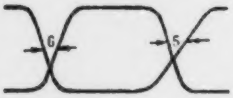

Figure 6.

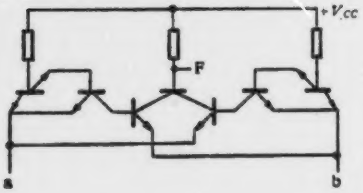

Figure 7. Exclusive-OR gate

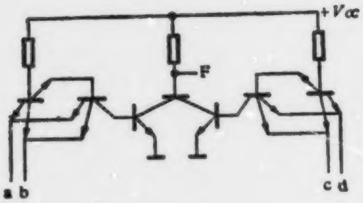

Figure 8. AND-OR-NOT gate

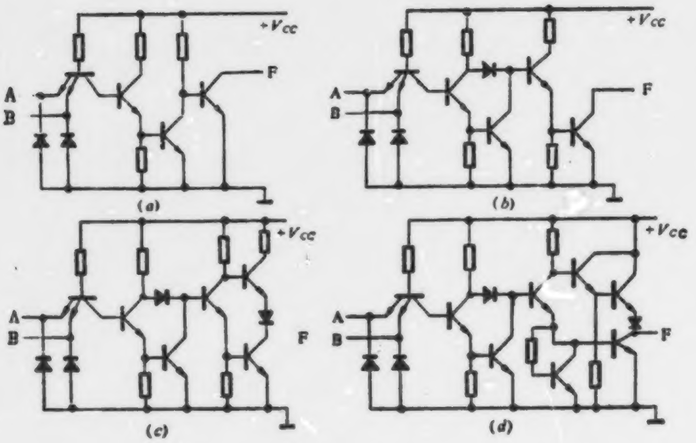
+V_{cc}
A
B
F
(a)
(b)
(c)
(d)

Figure 9. AND gate circuits

Advances in the D Trigger

The logic and circuitry of the common D trigger are illustrated in Figure 11 (a) and (b). This circuit has already been simplified, but the logic levels still maintain their original form. From the perspective of applications, the D trigger input generally should be equipped with a channel conversion switch, generally implemented by an AND-OR-NOT gate, thus the trigger's logic levels would be 5, and if the advanced D trigger as illustrated in Figure 12(a) and (b) is adopted, the logic levels will be commensurately reduced to 3 levels, which would also improve the repetition frequency of the trigger.

In principle, there are no essential changes in this circuit, but there are new changes in its logic circuit and circuit structure. Its working process is described below.

When M_t is at low potential, C and B output are high potential, and A gate is ready to accept the signal; when D_t input is "1", the forward transient jump relays the "1" to A almost immediately.

When M_t is high potential, C output is low potential, then this makes E output high potential, i.e., Q is set to "1". At the same time as this, through a maintenance circuit, C's low potential cuts off A gate and maintains its high potential. Here C gate's obstruction circuit of D gate is eliminated because A's high potential has already performed this function. It is also necessary to point out that at this time B output is low potential, and of necessity makes the arrival of this low potential later than the entry into force of A's maintenance potential. For this reason, making the resistance of B gate a little greater meets the needs of this delay. When D_1 input is 0, due to the negative transient jump, the 0 is very quickly relayed to A, and at the same time, the low potential at A also obstructs C gate. When M_t high potential arrives, D outputs low potential, then makes F output high potential, and E output low potential, i.e., Q is set to 0. In addition, since B outputs low potential, it also maintains the low potential of A.

From the above analysis we can see that the 'A' gate level actually may not occupy a logic level. Moreover, the addition of an input switch in the design is adding the signal to the emitter creating the conditions for a transient jump, thus this is equivalent to eliminating two logic levels. Experiments indicate that the speed is clearly improved.

Summarizing the above, the introduction of the new simplified circuit not only improves speed, but also improves integration. This is the advantage of the improved D trigger and when used to make a medium-scale register components, its superiority can be even further exploited.

The range of applications of the simplified circuit is very broad. Not only can it be used to build special use circuits, but also can systematically form a series of logic circuit components, such as four-bit function generators, eight-bit counters, eight-bit buffers, nine-bit odd-even checkers, four-bit channel shift switches, four-bit comparators, twin two-bit decoders, encoders, and shifters. All of these devices are of the DT^2L series. Due to limitations of space, we will not cite them one by one.

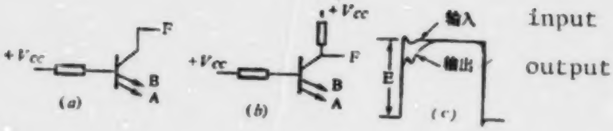
+Vcc
F
B
A
(a)
+Vcc
+Vcc
F
B
A
(b)
输入
input
输出
output
E
(c)

Figure 10. Simplified AND gate circuits and waveforms

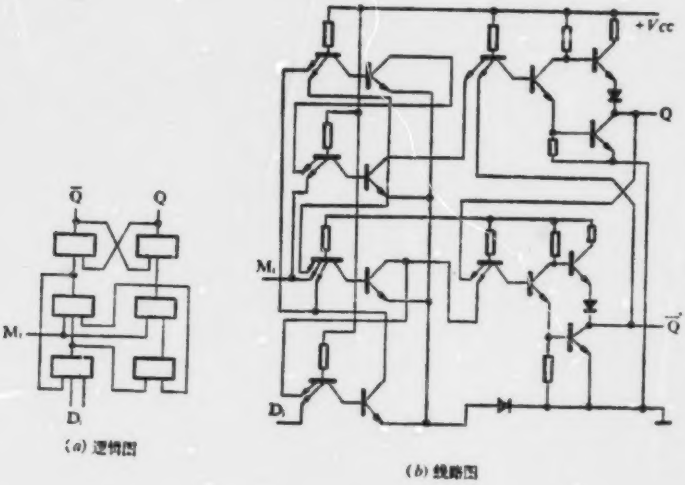
Q̄
Q
M₁
D₁
(a) 逻辑图
+Vcc
Q
M₁
Q̄
D₁
(b) 线路图

Figure 11. Commonly used D type triggers

a. Logic map
b. Circuit diagram

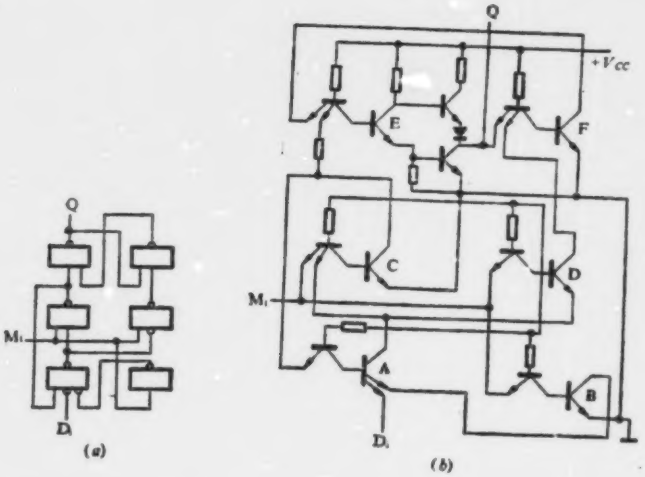
Q
M₁
D₁
(a)
Q
+Vcc
E
F
C
D
M₁
A
B
D₁
(b)

Figure 12. Improved D-type trigger

Conclusion

The basic gate circuit and sequence circuit of this circuit system was proposed a long time ago, and throughout a great deal of experimental and design work has been done with a number of comrades. Comrades of the Shanghai Radio Plant No 19 did technological experiments, and obtained excellent results. I believe that in-depth research and development of this circuit system will play a unique role in the development of China's integration technology.

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APPLIED SCIENCES

ADMITTANCE OF RECTANGULAR WAVEGUIDE OF SLOT ARRAY MEASURED

Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 7 No 3, May 83 pp 227-231

[Article by Li Zhixin [2621 4249 2450], Xi'an Electronic Technology Application Institute: "A Simple Method for Measuring the Admittances of Slot on H-plane of Rectangular Waveguide"*]

[Text] I. Introduction

The serial feed waveguide H-plane slot array antenna is a widely used antenna type. The relationship between the waveguide slot conductance and the geometrical dimensions of the slot is the foundation for designing this type of antenna and the frequency characteristics of the slot admittance is an indispensable basis for analyzing the antenna's frequency characteristics. Although the formulas for theoretical analysis can be applied in designing a waveguide slot array antenna,[1] there are some irregularities between the results obtained and the actual situation; therefore, before design, the conductance of the waveguide antenna is measured. Because the conductance of a single slot is rather small, it is difficult to measure accurately and in addition, there is coupling between the slots, thus people generally measure the slot conductance of many (at least 20) slots in the array. Generally the method of measuring the S parameter is used, i.e., measuring the shift of the wave node point and finding the conductance through plotting. This method of measurement is extremely tedious and accuracy is hard to guarantee. Some others use the traveling wave power method,[2] but this only gets the conductance at the harmonic frequency. We have yet to see any reports of a simple and direct method of measuring the frequency characteristics of slot admittance. To analyze and predict the frequency characteristics of a serial feed waveguide H-plane slot array antenna and improve the antenna's broad-band performance, this paper proposes an easy, computer-aided method of measuring the admittance frequency characteristics in a slotted array and presents the results of measurement. From the results it can be seen that the frequency characteristics of slot admittance are regular.

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II. Propagation Characteristics of Waveguide H-Plane Slot

As illustrated in Figure 1

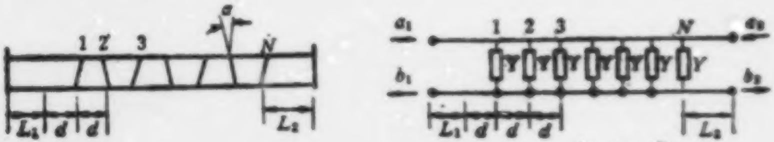


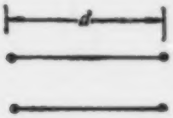
Figure 1 Waveguide H-Plan Slot Array and Its Equivalent Circuit

$$\begin{bmatrix} a_1 \\ b_1 \end{bmatrix} = [T] \begin{bmatrix} b_2 \\ a_2 \end{bmatrix}, \qquad (1)$$

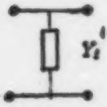
in which

$$[T] = \begin{bmatrix} T_{11} & T_{12} \\ T_{21} & T_{22} \end{bmatrix}. \qquad (2)$$

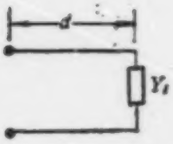
The propagation matrix of the equivalent circuit elements is



$$[Q]_d = \begin{bmatrix} e^{j\beta d} & 0 \\ 0 & e^{-j\beta d} \end{bmatrix}, \qquad (3)$$



$$[T_0] = \begin{bmatrix} 1 + \frac{1}{2} y_i & \frac{1}{2} y_i \\ -\frac{1}{2} y_i & 1 - \frac{1}{2} y_i \end{bmatrix}, \qquad (4)$$



$$[T]_i = [Q]_d [T_0]_i. \qquad (5)$$

The total propagation Matrix of the measured slot is

$$[T] = [T]_{L_1} \cdot \prod_{i=1}^{N} [T]_i \cdot [T]_{L_2}. \qquad (6)$$

Let

$$y_i = g_i + j b_i, \qquad (7)$$

when the total number of slots N>20, the fringe effect can be overlooked, at this time

$$y_i \approx g + jb. \qquad (8)$$

Let

$$[T] = \begin{bmatrix} T(1) + jT(2) & T(3) + jT(4) \\ T(5) + jT(6) & T(7) + jT(8) \end{bmatrix}, \qquad (9)$$

$$T_{11} = \sqrt{T^2(1) + T^2(2)}\, e^{j \operatorname{arc\,tg} \frac{T(2)}{T(1)}}, \qquad (10)$$

and the scattering matrix parameter

$$S_{21} = |S_{21}|e^{j\varphi_{21}}, \tag{11}$$

because

$$S_{21} = 1/T_{11}, \tag{12}$$

therefore

$$|S_{21}| = 1/\sqrt{T^2(1) + T^2(2)}, \tag{13}$$

$$\varphi_{21} = -\text{arc tg}\,\frac{T(2)}{T(1)}. \tag{14}$$

III. Method for Measuring Slot Admittance

The length L of the object illustrated in Figure 1 to be measured is

$$L = L_1 + Nd + L_2. \tag{15}$$

The phase difference between the slot array and all waveguides of similar length is

$$\Delta\varphi = \varphi_{21} - \beta L = -\text{arc tg}\,\frac{T(2)}{T(1)} - \beta L, \tag{16}$$

in which

$$\beta = \frac{2\pi}{\lambda}\sqrt{1 - (\lambda/2a)^2}. \tag{17}$$

If we measure $\Delta\varphi$ and $|S_{21}|$ of each frequency, we can solve the group of simultaneous equations eqs (13) and (16)

$$\left.\begin{aligned} |S_{21}| &= 1/\sqrt{T^2(1) + T^2(2)} \\ \Delta\varphi &= -\text{arc tg}\,\frac{T(2)}{T(1)} - \beta L. \end{aligned}\right\}. \tag{18}$$

Solving this group of simultaneous equations one can find the slot conditions g and admittance b. The g and b found are the admittance of each slot when coupled, i.e., the admittance of the array.

IV. Example of Measurement and Results

Our test sample was a BJ-100 waveguide with 30 slots open on the H-plane. Slot inclination was the same, interval was d=056λ_g (as illustrated in Figure 1), and resonated to frequency f_0. We used a microwave network analyzer within a frequency range of $f_0 \pm 500$ MHz and measured the $|S_{21}|$ and $\Delta\varphi$ of the test sample at $\alpha = 10°$, 12°, and 17°. The results are illustrated in Figures 2(a) and (b). Further, with the help of a computer we solved the binary simultaneous equation group (18), and obtained the values of g and b at different frequencies, as illustrated in Figures 3(a) and (b). On the basis of the measurement and

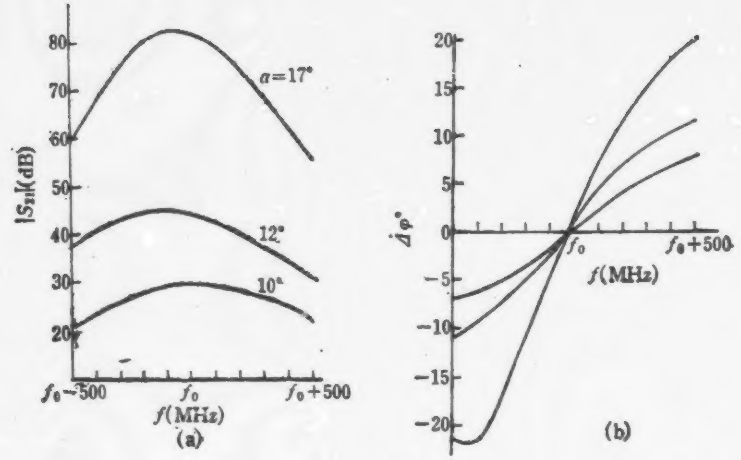


图2 实测的 $|S_{21}|$ 和 $\Delta\varphi$ 值

Figure 2. Test S_{21} and $\Delta\varphi$ values

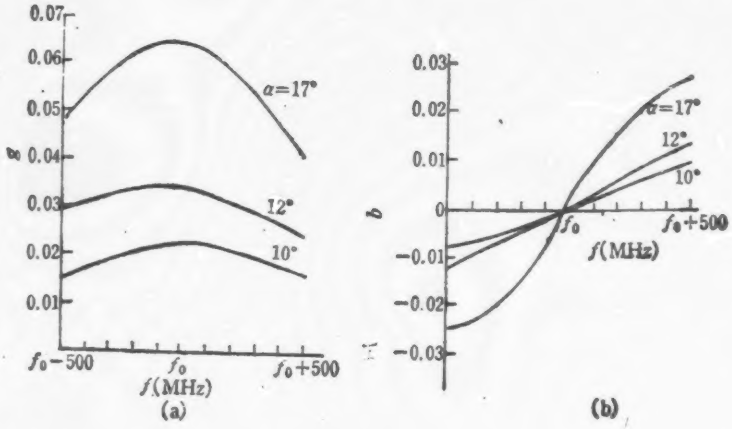
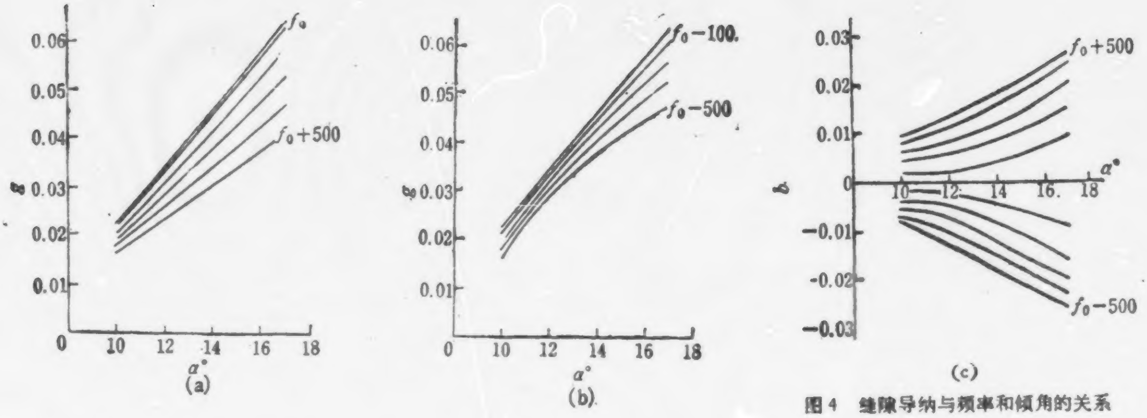


图3 测量结果

Figure 3. Measurement results

computation results we can draw the curve of the relationship of the parameters and α as illustrated in Figures 4(a), (b), and (c). Thus we could write approximately the relationship of g and b with the frequency shift $\frac{\Delta f}{f_0}$-- and



(a) (b) (c)

图 4 缝隙导纳与频率和倾角的关系

Figure 4. Relationship of slot admittance frequency and inclination angle

angle of inclination α,

$$g\left(\frac{\Delta f}{f_0}\right) = G(0)\sin^2\alpha - F\left(\frac{\Delta f}{f_0}\right), \tag{19}$$

in which

$$F\left(\frac{\Delta f}{f_0}\right) \doteq \begin{cases} 0, & \left|\frac{\Delta f}{f_0}\right| \leqslant 1\%; \\ 0.000675\alpha^\circ \left|\frac{\Delta f}{f_0}\right|, & \left|\frac{\Delta f}{f_0}\right| > 1\%; \end{cases} \tag{20}$$

$$b\left(\frac{\Delta f}{f_0}\right) \doteq 0.002\left(\frac{\Delta f}{f_0}\right)\alpha^{\circ 2}(1 + \mathrm{tg}^2\alpha). \tag{21}$$

when the frequency is the slot harmonic frequency,

$$g(0) = G(0)\sin^2\alpha, \quad G(0) \doteq 0.7695; \tag{22}$$

$$b(0) = 0. \tag{23}$$

the above results provide the basis for analyzing and predicting the frequency characteristics of the slotted array antenna. It must be pointed out that because the element distance d and the slot width are different for different slotted arrays, the coupling is also different and thus the constants in eqs (20), (21), and (22) are also different. So that the measurement results will conform better to the actual situation, care should be taken when measuring to ensure the same coupling situation when in use.

V. Conclusion

The tests prove that this method is simple and saves time. For design of slotted antennas, the precision of the measured results is sufficient for design of slotted antennas and provides a basis for analyzing and predicting the frequency characteristics of antennas.

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8226/12232
CSO: 4008/1038

S

APPLIED SCIENCES

DESIGN OF OPTICAL DETECTOR, RECEIVER DISCUSSED

Dalian DALIAN GONGXUEYUAN XUEBAO [JOURNAL OF DALIAN INSTITUTE OF TECHNOLOGY] in Chinese Vol 24 No 3, Sep 85 pp 121-124

[Article by Li Guoxiang [2621 0948 4382] and Xu Jingde [1776 2529 1795] of the Teaching and Research Section of Information Engineering at DIT: "Design of Optical Band Signal Detector"; manuscript received on 6 September 1984]

[Text] 1. Duality of Optical Band Signal Receiving Equipment and Radio Receiving Equipment

An optical band signal receiving unit is, in many aspects, similar to a radio receiver system. It is composed of a photodetector, receiver, and terminal. A radio receiver unit includes an antenna, receiver, and terminal. They are also similar in major technical areas such as sensitivity, frequency response (including selectivity), non-linear distortion, signal to noise ratio and miscode ratio. Based on these facts, the duality of an optical band signal receiver unit and a radio receiver unit is presented in this paper. The following dualities exist: photodetector versus receiving antenna, receiver versus receiver, and terminal versus terminal. Based on these dualities, a photodetector is considered as a receiving antenna. Then, an optical band signal receiving device can be modelled as a radio receiving device. Thus the design theory for radio receiving equipment can be used for optical frequency band signal receiving equipment.

Presently most people use PIN silicon photodiodes and APD avalanche photodiodes as photodetector components. The diode itself is equivalent to a constant current source with a parallel capacitor. Including the load, a constant current source with a parallel admittance.

Regardless of the mode and operating frequency, a receiving antenna is equivalent to a signal voltage source in series with an impendance, or a current source in parallel to an admittance. Based on the equivalent circuit, a photodetector is identical to a receiving antenna.

In terms of its internal structure, a photodetector, in addition to a light sensitive layer, is also equipped with a lens system which is a device of directivity. The maximum current can only be detected in the direction of maximum incidence. This is in analogy with the directivity of a receiving radio antenna and the duality exists.

In a light detecting device, between the photodetector and the receiver, there is an electrical circuit which has the same functions as that in a radio receiving device to suppress interference, limit noise, and select signal. To simulate a radio receiving device or the input circuit, various modes of circuits such as direct coupling and electrical induction (mutual induction) coupling circuits. Figure 1 shows a direct coupling input circuit. C_c is the dc insulating capacitor, L and C are the inductance and capacitance of the resonance circuit whose resonance frequencies are equal to the carrier frequencies R_1 and R_2, and R_3 and C_3 are the biasing elements of the amplifier. Figure 2 shows a mutual induction coupling circuit. A type input circuit, shown in Figure 3, can be evolved from these two types of circuits. L, C_1 and C_2 are in resonance at the carrier frequency.

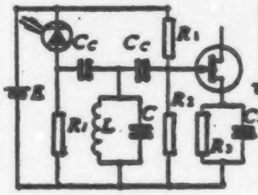

Figure 1

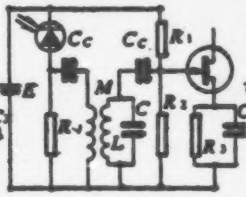

Figure 2

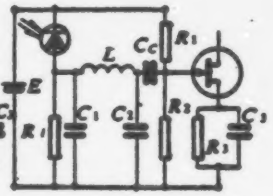

Figure 3

2. Key Issues in the Design of Photodetector and Receiver

Similar to designing a piece of radio receiving equipment, the design of an optical band signal receiver is centered around major technical issues such as sensitivity and frequency response.

The minimum incident light power of the photodetector is the sensitivity P_{oi} of the equipment. It is also the sensitivity of the photodetector. Its relationship with the sensitivity of the photodetector tube S and the sensitivity of the receiver P_{ri} can be derived based on Figure 4. In the figure the current source $I = SP_{oi}$. $_Ji$ and R_i are the output impedance of the detector. $_JR_r$ and the R_r are the input impedance of the receiver. In the event of conjugate matching, $R_i = R_r$ and $_JX_i = {}_JX_r$. The maximum power received from the detector is the sensitivity of the receiver.

$$P_{ri} \doteq (I/2)^2 R_i = (S^2 P_{oi}^2/4) R_i \qquad (1)$$

We can choose high sensitivity photodiodes in order to ensure the high sensitivity of the photodetector. However, we must notice that a photodiode is a capacitive element which is equivalent to a constant current source parallel to a capacitor. Furthermore, a photodiode is also a source of noise, providing quantum noise. Therefore, a detector comprised of a photodiode and a biasing circuit is no longer a constant current source with a parallel capacitor. Instead, it is a circuit with a current source and parallel resistance and capacitance. In this case, the detector not only provides quantum noise but also thermal noise which is often higher than quantum noise.

In order to ensure the high sensitivity of the receiver itself, it should have a high gain and a low noise index. Hence, we should select a high gain and low noise tube in the first stage to allow the entire unit to have a low noise index. A multi-stage amplifier should be used to achieve higher gain.

As an example, let us study the relationship between sensitivity, noise index and optimal coupling in the type input circuit shown in Figure 5. In the figure, I, C_d and R_i are photodetector parameters and C_i and R_i are the capacitance and resistance of the field effect tube. The remaining symbols stay the same. In the simplified circuit, $C'_1 = C_d + C_1$ and $C'_2 = C_i + C_2$. The resonance frequency of the loop is $f_o = 1/(2\pi\sqrt{LC})$ where $C = C'_1C'_2/(C_1+C_2)$. The transfer function of the input circuit is $H(f) = U_{ri}/I$. Based on the equivalent circuit it is not difficult to determine the transfer function at resonance:

$$H(f_0)=mR_lR_i/(R_l+m^2R_i)$$

where $m = C'_2/C'_1$. When $m = \sqrt{R_\ell/R_i}$, $H(f_o) = \sqrt{R_\ell R_i}/2$ is the maximum. Note that $H_{max} = \sqrt{R_\ell R_i}/2$, then the corresponding $m = \sqrt{R_\ell/R_i}$ is the optimal couple which is noted as $m_{oPt} = \sqrt{R_\ell/R_i}$.

The maximum voltage signal at the input end of the first transistor in the receiver using an optimally coupled π type input circuit is

$$U_{ri}=I\cdot H_{max}=SP_{oi}\sqrt{R_lR_i}/2 \qquad (2)$$

From the point of maximum transfer, the photodetector can provide the maximum output if the coupling is maintained. From the viewpoint of minimal noise index, this coupling is also the best.

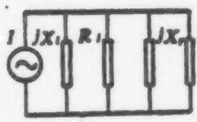

Figure 4

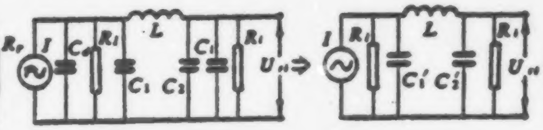

Figure 5

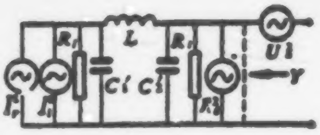

Figure 6

Figure 6 shows the equivalent noise input circuit where $I_d^2 = 2qI_oB$ is the dark current noise generated by the photodetector, $I_\ell^2 = 4KTB/R_\ell$ is the thermal noise generated by R_ℓ, $I_g^2 = 2qI_GB$ is the grid current noise of the field effect transistor and $U_n^2 = 4KTB \times 0.7\ (1+W)g_m$ is the carrier thermal noise and high frequency noise in the field effect transistor channel. In these equations, I_o is the dark current of the photodetector, q is the electronic charge, I_G is the grid current of the FET, K is the Boltzmann constant, B is the bandwidth of noise, W is the increment due to high frequency noise and g_m is the mutual inductance of the FET.

Usually $I_d^2 << I_\ell^2$ in PIN and I_d^2 can be neglected in determining the noise index. U_n^2 can be treated as the current sources on both sides of the dotted lines $I_n^2 = Y^2 U_n^2$, where Y is the total admittance. When $R_1 >> 1/\omega C_2^o$ is valid (which usually is), the noise index is

$$F = 1 + (I_g^2 + I_n^2)/I_{lo}^2 \tag{3}$$

where $I_{\ell o}^2$ is the noise at the output. In addition, $I_{\ell o}^2 = m^2 I_\ell^2$. By substituting I_g^2, I_n^2 and $I_{\ell o}^2$ into equation (3), we find the following when $I_g^2 << I_n^2$.

$$F_{min} = 1 + 2.8(1+W)/g_m R_l \tag{4}$$

The corresponding $m = \sqrt{R_\ell/R_i}$ happens to coincide with the coupling at maximum voltage output. Therefore, we can arrive at the following conclusions. The optimal coupling for minimum noise index coincides with that for optimum matching in a π input circuit. Please note that the F_{min} given in equation (4) was obtained by omitting the grid current noise of the FET. If it cannot be neglected, the outcome will be slightly larger. This formula can be used as the lower limit in the design.

The frequency characteristics are considered primarily in the design of the receiver, in analogy to the design of radio receivers.

3. Design and Development of Photodetector and Receiver for Frequency Modulated Signals

The subcarrier wave of the optical communication device for mining applications developed in this work is frequency modulated. The subcarrier frequency is 1 MHz. The bandwidth of the telephone signal is 0.3-0.4 kHz. The modulation index $\beta = 2.5$. The modulated bandwidth B = 22 kHz. The sensitivity of the optical receiving unit is $P_{o1} = -53dB_m$ ($0dB_m = 10^{-3}W$). The voltage of the power source is 6V and the power source is batteries.

The photodetector used is a model 2CU51901D PIN type photodiode. A π type circuit such as the one shown in Figure 3 is used between the detector and the receiver. The optimum coupling index is used. The first stage of the receiver employs a 3DJ9 FET. The main amplifier is a direct amplifying circuit. In addition to the input circuit and frequency discriminator there are two single coupling loops in the pre-amplifier and the main amplifier, respectively, to ensure the bandwidth and frequency requirements.

From the following given technical conditions that the optical sensitivity of the receiving equipment $P_{ot} = -53dB_m$, S = 0.5A/W for the photodetector and $R_1 = 100k\Omega$, equation (1) shows that the sensitivity of the receiver $P_{rt} = -98dB$. From equation (2) we get that the voltage at the grid of the FET $U_{rt} = 0.395mV$ (the input impedance of FET is of the order of MΩ and 1 MΩ is chosen as a lower limit). The input voltage of the frequency discriminator

U_d = 1V. Thus, the voltage gain of the receiver is 68dB. Because the preamplifier is single stage, a two stage main amplifier is used. If the gain in each stage is 23.5dB, the total gain is 70.5dB, which will meet the 68dB requirement. Hence, the gain assigned to each stage is 24dB for ease in practice.

The receiver has four single harmonic loops to ensure the bandwidth and frequency requirements. The frequency distortion coefficient is evenly distributed to each loop. The bandwidth of each loop at 3dB attenuation is B_1 = 50kHz. Q = 20(=1MHz/50kHz) with load, which is easy to materialize with L and C elements.

After testing, the sensitivity and frequency characteristics of the equipment were found to satisfy our requirements. At -13dB optical emission power with 40dB optical fiber attenuation, the reception is satisfactory. The range of communication reached 10 km without a relay station with good reception.

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APPLIED SCIENCES

DESIGN SCHEME OF 8MM HIGH-POWER COAXIAL MAGNETRON DESCRIBED

Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 6 No 3, May 84 pp 259-281

[Article by Chen Mingye [7115 2494 2814], Hongguang Electron Tube Plant of China National Electronic Devices Corporation: "A New Scheme for Designing a 8mm High-Power Pulse Coaxial Magnetron"]*

[Text] 1. Introduction

There have been two opinions on the feasibility of coaxial structure for magnetrons at 8mm wave band. One opinion is that when approaching the 8mm wave band, only an anti-coaxial structure can be used, while another opinion is that a coaxial structure can still be realized at 8mm wave band provided that high magnetic conduction material is employed for the terminal boot, and high strength oxygen-free copper is used for the internal resonant chamber, as well as employing line cutting method to process.

Currently, there is still difficulty in obtaining high magnetic conduction material for use in vacuum and air tight environments. The processing method of line cutting is still primarily employed in scientific research, and there is a certain degree of difficulty for batch production plants. Thus the following conflicts would be encountered when ordinary pure iron DT 8A is used as material for the terminal boot, while the internal and external resonant chamber are made of oxygen-free copperTUL:

(1) Due to the small size of the structure, the magnetic field in the interactive space is below the required intensity; if the distance between the upper and lower terminal boots is to be reduced to satisfy the magnetic field requirement, then there would be restriction from the height of the anode blade and the cathode axial height;

(2) The effective transmission area of the cathode is not large enough. There would be restriction from the axial height if the cathode's effective transmission area is to be enlarged; and

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* Received on 27 May 1983.

(3) Both the anode blade and the cylinder wall of the internal resonant chamber are very thin, a situation which not only presents poor mechanical strength, but also poses problems in heat conduction.

In order to overcome the above conflicts, we employ a new design scheme.

2. The design of anode aperture d_a

Kobayashi Daijiro's equation[1] of working voltage line is generally followed in computing the anode aperture d_a for coaxial magnetron in centimeter wave band.

$$d_a = 2N\lambda\sqrt{\frac{U_a}{(1-\sigma^2)(1884N\lambda B - 4.04\times 10^7)}} \quad (\text{cm}), \tag{1}$$

where N - number of resonant chamber;
λ - working wave length, cm;
U_a - working voltage, V;
σ - ratio of cathode diameter to anode diameter;
B - magnetic field intensity, GS.

The following problem will surface if the value of d_a computed in equation (1) is to be used to design the internal resonant chamber (internal chamber for short) for 8mm coaxial magnetron:

(1) The cylinder's inner diameter of the internal chamber being too small poses a limit on the maximum cross sectional area of the terminal boots. If pure iron DT 8A is used for terminal boots, the maximum magnetic field intensity of interactive space can only reach 8,000 GS, which is a long way from 11,000 GS, the magnetic field strength needed in reality.

(2) The anode aperture d_a being small causes a similarly smaller cathode diameter $d_k = \sigma d_a$. Now in order to increase the cathode surface area, the cathode axial length h_k has to be increased, and in doing so not only is the distance between the upper and lower terminal boots increased, causing even weaker magnetic field in the interactive space, but it also results in severe space parasitic oscillation at the ends.

Therefore we construct the following hypothesis to substantially increase the value of d_a.

It is well known that the threshold voltage of pth space resonant wave for n mode is determined by the Hartree equation[2].

$$U_{th} = \frac{\omega_n(r_a^2 - r_k^2)}{2(n+PN)}B - \frac{mr_a^2}{2e}\left(\frac{\omega_n}{n+PN}\right)^2, \tag{2}$$

where U_{th} - "anode threshold voltage" of the magnetron;
B - magnetic field intensity;
r_a - radius of anode;
r_k - radius of cathode;
n - mode number of oscillation;
p - space resonant wave number;
wn - oscillating angle frequency of the nth oscillation mode;
e - electron charge;
m - mass of electrion; and
N - number of anode resonant chamber.

If the magnetron is to operate at $n = \frac{N}{2}$ mode, P = +1, ie., the positive first space resonant wave, then when compared with the operation at basic wave mode ($n = \frac{N}{2}$, p = 0) under identical anode voltage and magnetic field intensity, the anode diameter can be substantially increased so that the conflict in designing millimeter wave band magnetron can be resolved.

When operating at the basic wave mode, $n = \frac{N}{2}$, p = 0 then

$$(n + pN) = \frac{N}{2}. \qquad (3)$$

When operating at the positive first space resonant wave, n = -n/-2, p = 1, then

$$(n + pN) = \frac{N}{2} + N = \frac{3N}{2}. \qquad (4)$$

When comparing equation (3) and equation (4), it can be seen that if N is only to be substituted with 3N in equation (1), the original design to operate in the basic wave π mode can be transferred to operating at the positive first space resonant wave. Thus the diameter of the anode should be:

$$d_a = 2(3N)\lambda\sqrt{\frac{U_a}{(1-\sigma^2)[1884(3N)\lambda B - 4.04 \times 10^{3}]}} \text{ (cm)}. \qquad (5)$$

If the value of the millimeter wave is to be put into equation (5), it is obvious that in the equation, inside the radical sign, the denominator's second term is much smaller than the first term, and thus can be ignored, therefore

$$d_a \approx 2.52\sqrt{\frac{N\lambda U_a}{(1-\sigma^2) \times 1000B}} \text{ (cm)}. \qquad (6a)$$

Converting the unit of U_a to the conventional kilovolt (kV), we have

$$d_a \approx 2.52\sqrt{\frac{N\lambda U_a}{(1-\sigma^2)B}} \text{ (cm)}. \qquad (6b)$$

It is apparent that the value of d_a computed according to equation (6b) is much larger than the value of d_a computed according to equation (1). Thus we can solve the design problem of millimeter wave band magnetron that is caused by using the computation equation of centimeter wave band.

3. Determination of the ratio, η of internal and external chamber diameters.

Currently, the value of η of coaxial magnetrons covering C wave band to Ku wave band is generally determined in the range of 0.25 - 0.41[1].

In designing an 8mm wave band pulse coaxial magnetron, we select $\eta = 0.55 - 0.58$ mainly for the consideration of:

(1) In order to achieve tuning with TE_{o11} mode within the entire frequency band, it is imperative that $\lambda_{col} > \lambda_{max}$ (λ_{col} is the cut-off wave length for TE_{o11}, λ_{max} is the maximum resonant wave length within the working frequency band range);

(2) In order to increase the ratio of external chamber storage energy to internal chamber storage energy so as to achieve the effect of stable frequency, we have to design a large L/h_a which is the ratio of the external chamber height L to the axial height of the anode blade h_a; and because L/h_a increases with increasing value of η, thus the value of η has to be maximized.

4. The design of box-shaped window

The box-shaped window for C wave band and X wave band has long been used in a wide range of applications. Nevertheless, can box-shaped windows be employed in millimeter wave coaxial magnetrons? We have performed a great deal of research work on that. Initially, 95 percent Al_2O_3 ceramic tiles were also used as window panes. However, no matter how thin the ceramic tile was made (0.4 mm), the frequency band could only be modulated to $f_c \pm 100$ MHz which obviously failed to satisfy the requirement of frequency modulation for millimeter wave band. Later we used 0.1 mm thick man-made mica sheet as window pane, to achieve an excellent frequency band characteristic for standing wave coefficient 1.1 within the $f_c \pm 1500$ MHz range, thus resolving the issue of realizing broad frequency band modulatable energy transfer window in 8 mm coaxial magnetrons.

5. Conclusion

It is reported that[1] the efficiency of an overseas 8 mm pulse coaxial magnetron SFD-319 was 19.76 percnet, 19 percent efficiency for SFD-315, and 13.9 percent efficiency for SFD-332.

Our 8 mm wave band pulse coaxial magnetrons constructed with the new design scheme have achieved an efficiency of 20.2 percent. They have been turned over to users, and certified by China National Electronic Devices Corporation.

Deep appreciation is extended to Qian Weizong [6929 1983 1350], associate professor in Electronic Engineering Department of Xian Jiaotung University, who gave consultation in the research and construction of the magnetron, as well as detailed verification and revision on this paper.

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13042/8309
CSO: 4008/1053

ENGINEERING STANDARD OF MOS MEMORY MODULE

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 21 No 11, [Nov] 84 pp 30-36

[Article by Chen Jingdong [7115 4842 2639], Zhu Zucai [2612 4371 2088], and Xu Zhongquan [1776 0112 2938]: "Engineering Standard of MOS Memory Module*"]

[Excerpts] (Note: Mere theoretical feasibility and correctness in principle, without scientific engineering design and rigorous implementation, not only make it impossible to create a machine which is easy to produce, low-priced, and performs dependably, but may even lead to catastrophic results. In the past, we have had many lessons in this regard. In this connection, the Information Storage Technology Group of the China Computer Society at its 1982 conference in Suzhou proposed increasing scientific activities in the area of engineering reliability, and asked the East China Computing Institute and the North China Computing Institute to jointly draft a paper on engineering standards of the MOS memory module, and to organize a discussion, held in February of 1984 at the Jiangsu Shazhou [Computer] Storage Plant, presided over by Comrade Chen Jingdong of the East China Computing Institute, with the participation of specialists from concerned plants and institutes all over the country. According to the results of the discussion, Comrades Zhu Zucai and Xu Zhongquan revised the standard, and it is being published by the editorial department of JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT]. It will further stimulate China's production and development of MOS memories. It will not only provide something to go by in the research and manufacture of memory units, but will also enable memory users to monitor and urge producers to carry the standard through. From the standpoint of developing China's computer industry, the study group will continue from now on to launch activities regarding engineering reliability. In addition, we hope concerned units will carry on more research tasks in this area, to improve the level of engineering design theories and related technologies, and we hope publishing departments will publish books in this area.--Huang Yuheng [7806 3768 3801])

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*Article contributed by the Information Storage Technology Group of the China Computer Society.

Preface

Mankind has entered the information society, and information storage is an important technology of the information age. Not only is it needed in computer design, but it is also indispensable in many kinds of electronic control equipment. MOS RAM is already widely used in many different fields. At present, domestic research and manufacture of computers is flourishing. In order to speed up the lead-time cycle of these machines and to enhance their performance reliability so as to promote the development of information storage technology, in February of 1984 the China Computer Society's storage technology group invited experts from concerned units throughout the country to Jiangsu Shazhou [Computer] Storage Plant to hold a meeting to examine and approve an MOS memory module standard, and a draft of the "standard" was approved. It combines the achievements of the past few years of experience in the research and manufacture of MOS memory; the data contained in the "standard" are derived from articles from two conferences on information storage technology and from the practical experience of the units represented by the participating experts. In the process of examining and approving this "standard," they not only took into consideration the present level of research and production in China, but also took note of the level of development of devices in the next few years. According to the principle of combining a scientific theoretical basis with practical needs, they have striven to reach the goal of combining principle and flexibility. But the rapid development of computer science technology has also brought to the "standard" some unavoidable limitations and shortcomings, which should be continuously revised and supplemented later on. But in any case, it has reference value to those in China who are engaged in computer systems engineering design, especially in plants specializing in MOS memories. At present, it will be very effective in the enhancement of the reliability of MOS memory engineering. It may be of use as a reference to the State General Bureau of Standards in working out a standard.

I. General Principles

1.1 This "standard" lists the testing standards and engineering design principles for the research and manufacture of MOS RAM devices; it does not go into the details of the production process.

1.2 Requirements for Testing Instruments:

(1) The voltage drop of the indicator used for DC parameter testing should be sufficiently small. In general, the internal voltage drop should be smaller than 1 percent of the working voltage of the tested loop.

(2) The load-effect of the indicator used for testing voltage parameters should be sufficiently small. In general, the internal resistance of instruments used for voltage indication should be larger than 1 MΩ/V.

(3) The band of oscilloscopes used for testing should be ≥1/3 tr, where tr is the minimum time rise of the tested signal.

(4) Digital voltmeters should be accurate to three decimal places.

(5) The program clock resolution of the testing instrument should be $\leq 0.5 \sim 1$ ns; for developing and manufacturing memories with a storage cycle larger than 300 ns, the testing resolution can drop to ≤ 2 ns.

1.3 Power Requirements for Testing:

The stability of stabilized voltage supply used for testing can allow an error of ±2 percent, with ripple voltage not larger than 0.50 percent.

1.4 Conditions for Testing Environment:

(1) All testing operations should be carried out on an electrostatically shielded table. The operator should be grounded.

(2) Testing of electrical parameters should be carried out under normal environmental conditions. Normal environmental conditions: air temperature is 20° ± 5°C, relative humidity 65 ± 15 percent, atmospheric pressure 750 ± 30 mmHg.

(3) Memory devices should be stored in an electrostatically shielded box.

II. Testing of MOS RAM DC Property Parameters and Several Engineering Processes

[. . .]

III. Testing of AC Properties

[. . .]

IV. Selection of Testing Graphs

Functional testing is one of the major testing items for MOS devices, and the selection of testing graphs has a great effect on the quality of the testing results. Different circuits and processes have different sensitivities to testing graphs. Extensive testing has shown that N graphs are more rigorous in testing the address coding portion, N^2 graphs are more rigorous in testing the disturbance coupling between storage cells, and $N^{3/2}$ graphs are between these two. There are many kinds of testing graphs for semiconductor memory devices, and each graph pays particular attention to testing a certain function of the memory device. For example, all "0"/all "1" can only do a preliminary check of the storage function of a memory device, but cannot check for trouble with decoders and storage cells.

[. . .]

V. Aging and Screening of Devices

[. . .]

VI. Memory Module Board Design

The quality of the module board is the key factor influencing the reliability of the memory device, and must be given sufficient attention in the process of development and production.

VII. Special Requirements for the Module Board Production Process

[. . .]

VIII. Testing of Memory Module Board

[. . .]

IX. Considerations of Layout in Medium and Large Size Domestically Designed Memory Cabinets and of Main Board Engineering Design

Printed main boards have the virtues of high assembly density, good electric performance, short production cycle, and the ability to eliminate noise signals arising because of loose wiring, and for these reasons printed main board structure is used at present in the production of all computers. The following are principles of main board production:

9.1 Card Layout:

(1) Data input and output cards should be near error-checking cards.

(2) It is preferable for storage board sequence cards to be near memory modules; if possible, they should be installed in the center of the memory module.

(3) Other cards should be arranged with the shortest possible routing between them.

(4) If conflicts arise in the arrangement of cards, handle them, according to the required degree of time-sequence accuracy, in the order of clock line, pulse line, drive line, potential line, neon indicator circuit lead wire.

9.2 Considerations of Main Board Engineering Design:

(1) The filter system must be perfect, and there should be positions left at both ends of the board for installing filter capacitors.

(2) Consideration should be given to the design of positions on the board for connecting matching resistors. Some need to have matching cards added.

(3) To make every point on the board even in voltage, and to keep the static potential difference small, use the method of lead-in from both top and bottom for the supply line. In a no-load state, the largest potential static difference for the various kinds of power supply must not exceed 5 mV.

(4) When there are not enough bus plane, a bus bar may be added. Connect the power supply from the bus bar directly to the card.

(5) The number of additional ground pins for the board should be determined by reference to the amount of manual routing; in general, the principle to go by is whether there is enough for use.

[. . .]

X. Considerations of Cabinet Ventilation and Power Supply System

(1) To assure good ventilation inside the cabinet, several axial fans should be installed to prevent heat accumulation. Generally, a temperature difference less than 3-5°C at the ventilation opening is desirable. (Note: Exceptions are smaller capacity memories made from a small number of packages, and memories made of low power consumption CMOS packages, because their total power consumption is very small and the temperature rise is low, so self-selected ventilation can be used.)

(2) Memories have a rather large pulse current. In order to improve power feed capability, the total power capacity should retain at least 1/3 of the remaining power. In addition, the power feed line should be short and thick, to ensure a small voltage drop and small amount of induction.

(3) Power supply for peripheral circuits and memory modules should if possible be separate.

(4) In systems assembled from 3-lead power supply MOS devices, the proper sequence should be followed for connecting and disconnecting power supply. Sequence for connecting power supply: first connect -5 V, then +5 V +12 V; sequence for disconnecting: first disconnect +12 V, +5 V, then -5 V. If the -5 voltage should drop, the +12 V +5 V should be automatically cut off in the ms measuring range in order to prevent damage to the MOS device.

(5) The hermetic seal of the cabinet must be satisfactory and the frame should be grounded, to avoid interference from external magnetic fields.

XI. Key Points of Diagnostic Program Design for Memory Modules

Although the MOS devices and module boards have undergone many different kinds of tests before the assembly of the storage module, after the assembly, the necessary condition for ensuring the reliability of the memory is to run complete diagnostic programs through it. The emphasis of the diagnostic programs is not the testing graphs of the individual chips, but problems such as the multi-addressability and disturbance between positions. In general, the following should be taken into consideration: [. . .]

XII. Anti-Interference Testing

When the system is running, artificially create bad conditions, such as a strong electromagnetic field, power disturbance, ray interference, etc. Specialized equipment may be used for testing, or if none is available, the following simple methods may be used to test reliability: [. . .]

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APPLIED SCIENCES

APPLICATION OF MICROCOMPUTER IN COMPOSING, EDITING NEWSPAPER

Dalian DALIAN GONGXUEYUAN XUEBAO [JOURNAL OF DALIAN INSTITUTE OF TECHNOLOGY] in Chinese Vol 24 No 3, Sep 85 pp 133-136

[Article by Zuo Fengxian [1563 7685 6343] and Tang Huanwen [0781 3562 2429] of the Department of Applied Mathematics, and Zhang Lidong [1728 4539 2639] of the Dalian Experimental High School: "Applications of Microcomputer in Newspaper Composing and Editing"]

[Text] I. Structure Design in Newspaper Composing and Rough Program Flow Diagram

1. Brief Introduction

In publishing newspapers, composing and editing work must be designed ahead of time. This type of work is very complex and requires a lot of time for repeated design and modification. In order to reduce the work load, beautify the layout and enable newspapers to report major events timely, we developed an automated newspaper layout design system to replace manpower by a microcomputer. In a real example, the color graphics functionality of the microcomputer was successfully applied to plot the desired layout pattern.

The so-called newspaper layout design (BZHB) involves the following: the total capacity of a certain edition of the newspaper S, the number of articles to edit n, the numbers of words in various articles $B_1, B_2, \ldots, B_n$, and the type of each article (such as headline, picture and ordinary communication and commentary) are given in sequence. It is required to design a layout to satisfy that 1) the total capacity is S, 2) $B_1+B_2+\ldots+B_n=S$, 3) each article is not allowed to cross its boundary, 4) the headline must be clearly displayed and its contents follow, 5) pictures and articles with fancy borders are not permitted to be next to each other, 6) the texts and graphics in articles with pictures and fancy borders must be clearly labelled, and 7) the "seating" number of each article must be written in the layout to allow the editor to examine and modify, as well as to allow the worker to typeset.

It is a meaningful task to let a microcomputer design an ideal layout to satisfy the above requirements. The entire design plan in the BZHB system introduced here has already been realized on an Apple II microcomputer using advanced BASIC. Furthermore, it passed an actual application to design the front page of DALIAN RIBAO [DALIAN DAILY NEWS]. The results are shown in Figure 2 and the layout is shown in Figure 3.

2. Supporting Hardware

Apple II with monitor, Model X-YMP1000-21 plotter and Model PX-80 line printer.

3. Supporting Software

1) Apple II DOS 3.3 Disk Operating System, 2) Apple Soft BASIC interpreter and 3) Apple II MP 1000-Z1 plotting language.

4. User Application Program

1) ZZ01, the main composing and editing control program, controls six functional modular programs. 2) ZZ02, the main plotting control program, controls six plotting programs. 3) ZZ03 is the file initialization program. The main composing and editing control program, ZZ01, can be divided into five functional parts: the main control which includes the selection of functionality and installation of switches, data input and processing which includes modules for manuscript input and processing and data file accessing, retrieval which includes the cyclic retrieval module and the obstacle processing module, output, and plotting. These parts are linked according to Figure 1. Figure 2 is a rough flow diagram of the program.

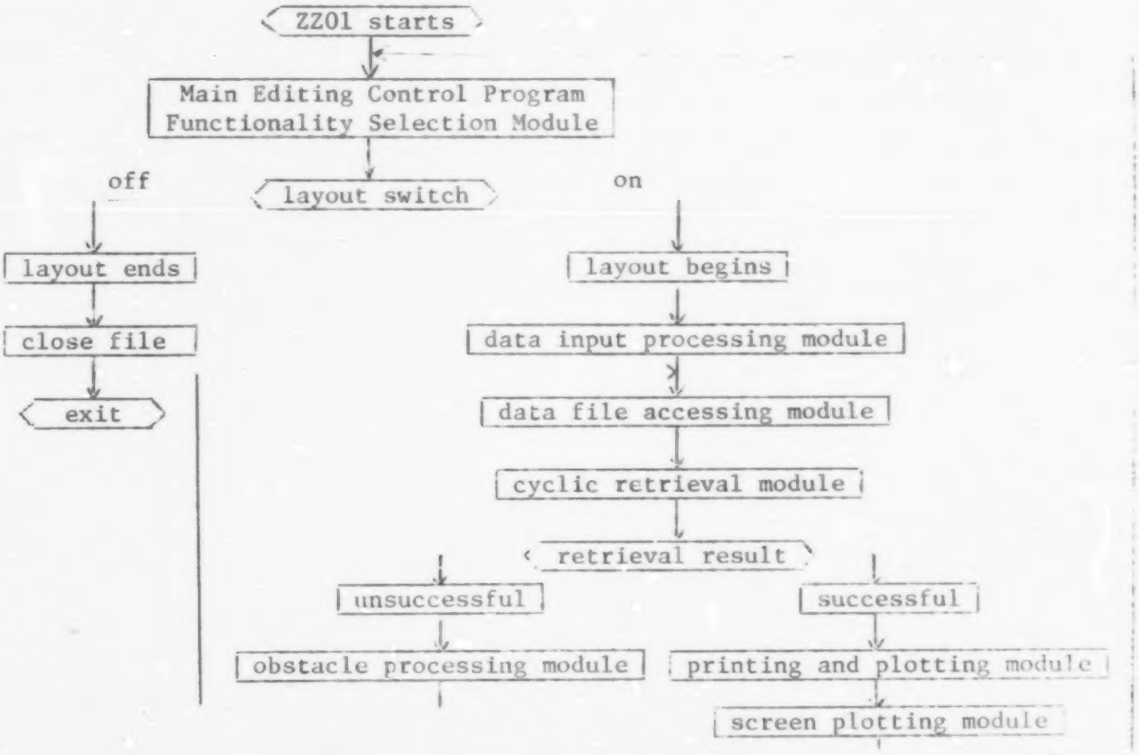
ZZ01 starts
Main Editing Control Program
Functionality Selection Module
off
layout switch
on
layout ends
close file
exit
layout begins
data input processing module
data file accessing module
cyclic retrieval module
retrieval result
unsuccessful
successful
obstacle processing module
printing and plotting module
screen plotting module

Figure 1

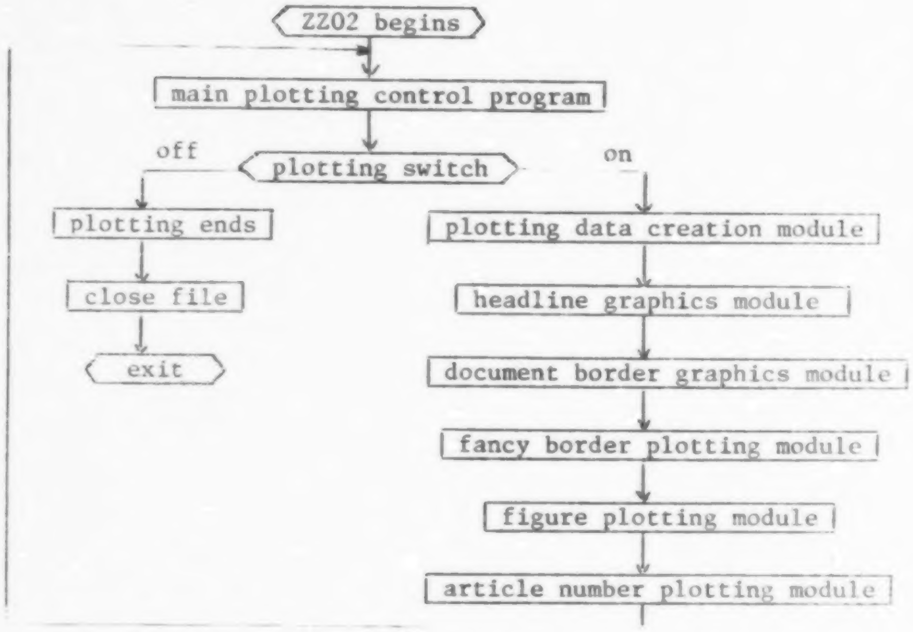
ZZ02 begins
main plotting control program
off
plotting switch
on
plotting ends
close file
exit
plotting data creation module
headline graphics module
document border graphics module
fancy border plotting module
figure plotting module
article number plotting module

Figure 2

II. Program Design of BZHB

1. Description of the Method

In designing the automatic newspaper layout by microcomputer, we adopted a simulated manual layout method. The fast speed of the microcomputer and the abundant external storage resources are fully utilized. Data files for the total words in each edition and the total number of articles are established. Information in data files on external storage can be used in sequence to plot various ideal layouts. When a layout design is required, the initial data (number of articles) is used to compare the corresponding areas in the data file and the key retrieval sequence. Furthermore, a pair of multiple retrieval techniques are used to "seat" the data correspondingly. In the meantime, we finish manuscript sequencing and fancy border positioning to accomplish retrieval. If retrieval is unsuccessful, we can use the function to reduce or expand similar type of article automatically to eliminate the obstacle until the retrieval is successful.

2. Input and Processing of Initial Data

In order to make it easy for the end user and to save computer time, it is only necessary to enter the following data in running this program: 1) total number of words on page S, 2) total number of articles on the page n, and 3) number of words in each article B_1, B_2,...,B_n. In addition, we must enter them according to the sequence of headline, picture and general communication and commentary. (This arrangement not only facilitates the end user but also greatly simplifies the program design.) We also specified that an extra label 1 must be added in front of the number of words B_1 of an article with fancy borders. For instance, 600 should be entered as 1600. (This arrangement frees the user from entering additional information for such articles.)

After considering the complexity of the problem and possible error in manual control, the program introduces various techniques to judge whether the data are rational. A manuscript data input processing module was compiled to determine whether the data satisfy the following relation:

$$S=\sum_{i=1}^{n} B_i$$

When this relation is not satisfied, the system prompts the user to modify and re-enter the data. The fancy border label 1 is treated by separation to take 1 or 0 and store in R(n) for the user to plot later.

3. Output of Results and Plotting

This part is directly supplied to the end user to ensure the integrity of the data and clarity of the format. The output includes two parts: 1) printing a table such as Table 2 and 2) plotting a sample page such as the one shown in Figure 3.

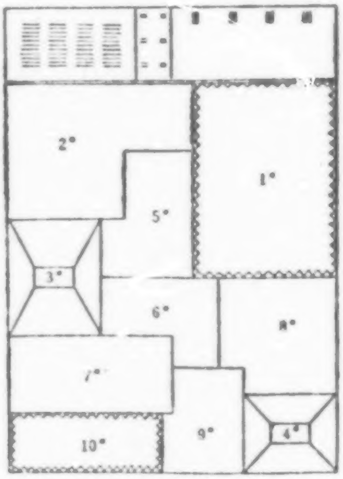

Figure 3

The plotting program was designed to use the MP1000-21 plotting language. Six plotting modules were designed to explore the pattern. Expressions are used as the plotting coordinates in order to minimize the statements required to finish plotting the entire page including headlines, fancy borders, pictures, and serial numbers.

III. File Organization in BZHB

In order to meet different layout requirements, the program was designed with a data file technique. The file is serial and each record is composed of a 2(m+2) area (m is the number of vertices of the article in the layout). Table 1 shows the format of a record. The information stored is in integer form and the data structure is relatively simple. The data stored is compressed to a minimum to allow the storage of a great deal of information with limited external storage facility. In addition, the speed to process integers is also appreciable.

Table 1. Format of a Record

Name of information domain	Words in article	Number of vertices	Abscissa of vertex 1	Ordinate of vertex 1	......
Content	B_i	m	x_0	y_0	......

Name of information domain	Abscissa of vertex m	Ordinate of vertex m	Abscissa of center	Ordinate of center
Content	x_{m-1}	y_{m-1}	x_m	y_m

IV. Special Features of BZHB

1. It is only required to enter n+2 initial data points in running this system. The amount of data is small and they are simple. It is easy for the end user.

2. The program structure is simple and its running speed is fast. It may be used by daily newspapers which require page layouts on a day-to-day basis and becomes a powerful tool.

3. A data base containing various layout information is created by taking advantage of external storage facilities of the microcomputer. Consequently, the program is simplified to run faster.

4. As long as a sufficiently large data base is created to include an inventory of various layouts, the user may choose a desired layout number. Or, he may use a portion of the program to plot the layout immediately, instead of entering n+2 data points to facilitate the user further and save time.

5. In addition to printing all the layout information, the program is capable of displaying color patterns on the monitor or plotting them on the plotter for direct viewing by the editor. If the layout is not satisfactory, modifications and changes can be done immediately.

V. An Example

In this example the layout design of the front page of DALIAN RIBAO is shown. The upper portion (one-sixth of the page) is the headline. The upper right remains fixed for important news with words ranging from 550-600. In addition to the headline, the page holds 10 more articles, $n=10$. The total words in the page is $S=7000$. The articles include two major news articles $B_1=1060$ and $B_2=1540$, two articles with pictures $B_3=600$ and $B_4=420$, and six ordinary communications and commentaries $B_5=720$, $B_6=690$, $B_7=400$, $B_8=580$, $B_9=510$ and $B_{10}=480$. (Titles and figures are converted into words.) Let B_2 and B_{10} be the ones with fancy borders. Therefore, $B_2=11540$ and $B_{10}=1480$. When S, n, B_1, B_2,...,B_{10} are entered, BZHB very quickly provides results as shown in Table 2 and layout as shown in Figure 3.

Table 2

SHU CHU JIE GUO,

No.	<I>	B(I)	<1/0>
#1:	<2>	1540	<1>
#2:	<1>	1060	<0>
#3:	<3>	600	<0>
#4:	<4>	420	<0>
#5:	<8>	580	<0>
#6:	<9>	510	<0>
#7:	<5>	720	<0>
#8:	<6>	690	<0>
#9:	<7>	400	<0>
#10:	<10>	480	<1>

The authors would like to thank the editors and reporters of DALIAN RIBAO for their support and assistance.

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APPLIED SCIENCES

CZOCHRALSKI GROWTH OF TUNABLE LASER CRYSTAL $BeAl_2O_4:Cr^{3+}$

Beijing GUISUANYAN XUEBAO [JOURNAL OF THE CHINESE SILICATE SOCIETY] in Chinese Vol 12, No 2, Jun 84 pp 131-136

[Article by Ma Xiaoshan [7456 4562 1472], Hou Yinchun [0186 0603 2504], Wang Siting [3769 0934 0080], Shen Yafang [3476 7161 5374], and Jin Zongru [6855 1350 0320]** all of Shanghai Institute of Optical and Fine Mechanics, Chinese Academy of Sciences*]

[Text] Abstract: Optically homogeneous alexandrite blanks, 100 mm in length and 20 mm in diameter, were grown by Czochralski technique using rf heating. These blanks were fabricated into 90 mm long 5 mm diameter c-axis laser rods. Tunable laser output was obtained experimentally. Spectroscopic characteristics of the crystal were presented. Problems such as prevention of BeO contamination, chrysoberyl formation kinetics and melt aging are also discussed.

I. Introduction

Chrysoberyl containing various impurities is a synthetic gem. Its growth and properties had been studied long ago [1]. Recently, chromium containing alexandrite was used as a tunable laser working substance and attracted some attention. This type of laser has a simple structure, high output power and wide tunable range. It can be operated at room temperature and the material has good physicochemical and mechanical properties [2]. Recently an alexandrite laser has been used in the annealing of ion implanted semiconductors. It was proven that silicon has a stronger absorption coefficient in this wavelength region (≈ 750 nm). The result was better compared to that of the $YAG:Nd^{3+}$ laser [3]. In military applications, enemy countermeasures will become ineffective when such laser is used in ranging and target designating because of its tunable output wavelength. It is apparent that this laser will be widely employed in many areas such as laser spectroscopy and frequency

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**We hereby express our thanks to: Comrades Lu Minghua [7120 2494 5478] and Zhu Rude [2612 3067 1795] for their participation in this work, to Comrades Wu Guangzhao [0702 0342 3564] and Zhang Xiurong [1728 4423 2837] for their assistance in measuring fluorescence spectrum and absorption spectrum, and to Lupu Calin for his assistance in measuring ultraviolet absorption spectrum.

modulated optical communications. Therefore, this crystal growth process and its applications in laser are being studied in countries such as the United States, the USSR and Japan [4-7].

Alexandrite and olivine are isomorphous. The space group is Pmnb***. It belongs to the orthorhombic system. Each unit cell contains four molecules [3]. The cell constants are $a_0 = 5.4756$Å, $b_0 = 9.404$Å and $c_0 = 4.4267$Å***. The oxygen atoms in chrysoberyl are in a distorted dense hexagonal pile. A beryllium atom is located in the body center of the oxygen tetrahedron, occupying 1/8 tetrahedral interstitial lattice. An aluminum atom is in the center of an oxygen octagon, occupying 1/2 of an octagonal interstitial lattice. Aluminum atoms have two lattices. Al_1 has a distorted center of symmetry and Al_2 is on a face symmetric lattice. The average Al_1-O bond is 1.890Å and the average Al_2-O bond is 1.938Å. Because of the bond distance, larger atomic radius species such as Cr or Fe have priority over Al_2.

II. Materials

Beryllium Oxide: Product of the Sixth Smelting Operation Plant of Hunan Shuikoushan Mining Administration, >99.9 percent pure. The impurity contents are shown in Table 1.

Table 1 Impurities in BeO powder (ppm)

Si	Fe	Pb	Mg	Cr	Ni	Al	Cu	Mn	K
54	122	11	66	30	6	69	0.4	11	18
Ca	Sb	Co	Ag	Bi	Ti	Mo	Zn	Na	
68	<3	<3	<0.9	<9	<3	<3	<10	68	

Aluminum oxide with ruby lumps was grown by a flame method. Its impurities are shown in Table 2.

Table 2 Impurities in ruby lumps (ppm)

Cr_2O_3	Na_2O	Fe_2O_3	CaO	MgO	CuO	MnO	PbO	ZnO	K_2O
0~0.06%	<10	<10	<10	<10	<10	<10	<10	<10	<3

Chromium oxide was chemically pure powder.

The binary phase diagram of Al_2O_3-BeO is shown in Figure 1. From Figure 1 one can see that $BeAl_2O_4$ is a congruent melt, therefore, they are matched stiochiometrically.

Because of the high toxicity of BeO powder, its content in air should not exceed 1 μgBe/m^3: otherwise, the operator might be poisoned. Special precaution should be taken in the entire crystal growth process to avoid poisoning due to BeO dust. BeO was weighed in a glove box. Combined with other measures, the beryllium content in air could be maintained at less than 0.5 μg/m^3.

***In order to have a consistent discussion, a_0, b_0, and c_0 are determined in accord with ASTM 10-82, hence different from those in reference [8].

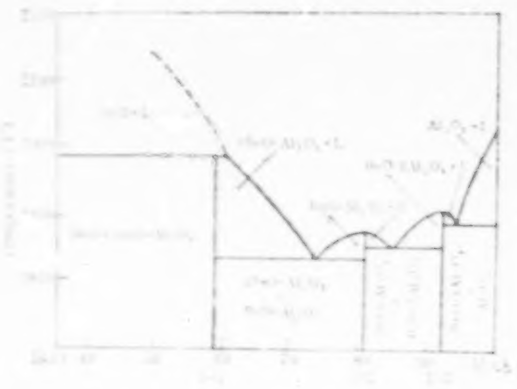

Fig.1 Phase diagram of BeO-Al_2O_3 system after reference[11]

Roughly weighed BeO was placed in an aluminum crucible and heated to 1350°C for 12 hours. The volume of BeO was contracted to a sintered block approximately half the original size. Because of the partial reaction between BeO and Al_2O_3, a small amount of BeO adhered to the wall of the crucible. However, the BeO sinter was not affected. It was not necessary to remove the small amount of materials sticking to the wall either. Stoichiometric amounts of BeO sinter, ruby lumps and chromium oxide powder were weighed and melted in an iridium crucible. We also attempted to fire up BeO, γ-Al_2O_3 and Cr_2O_3 in stoichiometric amounts at 1300°C for 6 hours. X-ray pattern showed that the alexandrite phase has already essentially been formed. But, the volume of this mixture did not contract significantly even after heating at 1400°C for 24 hours. It was unfavorable to be used in experiments. If the mixture is pressed, it will be more difficult to prevent beryllium powder from spreading. The BeO sinter and ruby lumps used in our work not only simplified the procedures but also reduced BeO contamination. Results proved that good quality $BeAl_2O_4$:Cr^{3+} crystals could be obtained by using these materials in conjunction with an appropriate growth technique.

III. Formation of Alexandrite

The formation kinetics of alexandrite was studied in detail experimentally by E.G. [illegible]amin [9] and G.V. Bukin et al. [6]. After heating at 1400°C for 10 minutes, a mixture of BeO and Al_2O_3 powder could be mostly converted to alexandrite. However, our experiments showed that 1-8 hours were required from melting the starting materials to initiating the chemical reaction and finally to form alexandrite. The specific time is determined by the temperature field. This difference was obviously caused by the various physical states of the raw materials. Mixtures of fine particles were used in the literature [6,9], while BeO sinters and ruby lumps were used in our work.

Experimentally, BeO was usually placed on the bottom and ruby lumps on the top of the crucible. The temperature was raised gradually to melt the mixture. It was observed that the fluidity of the melt was poor. Because of the slow mixing rate, the initial melt was not homogeneous. This inhomogeneity will seriously affect crystal growth.

The power mV_P and crucible bottom temperature mV_T were simultaneously recorded in the experiment; both were in relative values. The numerical values varied with changing experimental conditions. A typical situation is shown in Figure 2. Curve 1 is the variation of mV_P with time, manual or automatic control. At point A, the power was increased manually. Curve 2 shows the mV_T vs time curve. From this figure one can see that mV_T could rapidly respond to changes in mV_P with a slight lag. At one particular moment, 6 hours after the raw materials were melted, mV_T suddenly dropped as shown in Figure 2B. This phenomenon is called the temperature flip-flop effect. It could be considered that the melt was not thoroughly mixed before this time and the top portion was rich in Al_2O_3. After thorough mixing, the radiation transmittance of the melt increased drastically, leading to a huge decrease in temperature at the bottom of the crucible as shown at point B in Figure 2. It was proven that the crystal grown before the temperature flip-flop was not transparent. Only new crystal grown under this non-transparent crystal after the temperature flip-flop is transparent*.

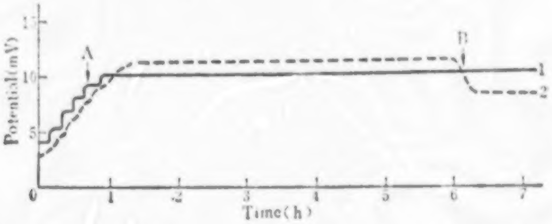

Fig.2 Curves obtained by XWT-264 recorder for input power and temperature at the bottom of the crucible respectively 1——mV value from pickup coil (mV_P) ; 2——mV value from silicon photocell (mV_T)

The temperature at the bottom of the crucible could also be affected by melt convection. It was demonstrated experimentally that the presence of temperature flip-flop is only related to the mixing condition of raw materials and the geometry. The temperature rising rate and melting temperature could only affect the timing of the flip-flop, not whether it occurs. Furthermore, temperature flip-flop has not been observed after a melt is cooled down and then heated up again. These facts are inconsistent with the temperature drop corresponding to convection. We believe that the melt is homogeneous when the temperature flip-flop takes place. The reaction is complete and the radiation transmittance is increased to reduce greatly the temperature at the bottom of the crucible. Because it is homogeneous the crystal obtained is transparent.

IV. Melt Aging

As described above, it is easier to obtain transparent single crystal alexandrite if the seed is planted in time immediately after the flip-flop.

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*Color crystal photo is omitted.

Satisfactory results cannot be obtained if seeded ahead of time. If the temperature is not well adjusted to grow crystal in time after the flip-flop, experiments will also fail. In this case, white or semi-transparent crystals may be obtained. The crystal grown at high temperatures appears to be especially transparent and bright. Sometimes, crystal edges and crystal planes may be present. However, after the crystal is grown to a certain length, the top of the crystal becomes opaque and its surface flakes off. Finally, it breaks off. This effect occurs more frequently when left over materials are used in the crystal growth process. Another interesting thing is that when a transparent crystal falls into the melt by accident and is remelted, the new crystal grown is an opaque material.

R.C. Linares [11] found that transparent alexandrite could not be obtained using an aged melt. It was described as a "melt aging" effect. We generalized phenomena to melt aging. X-ray diffraction analysis of the transparent and opaque crystals showed no significant difference between their diffraction peaks. The differences were found in a few weak peaks and some slight shifts in the diffraction pattern. These discrepancies are being further studied.

We have the following hypothesis with regard to melt aging: A high temperature melt is not totally beryllium aluminate. It is possible to have some Al_2O_3 or BeO and $3BeO \cdot Al_2O_3$ or $BeO \cdot 3Al_2O_3$ present. The aluminum rich constituent has a higher density and the beryllium rich constituent has a lower density. Gravity causes the aluminum rich constituent to sink. In our experiment, the geometric arrangement of the raw materials in the crucible was that the BeO sinter was on the bottom and ruby lumps on top. Therefore, a transparent $BeAl_2O_4:Cr^{3+}$ crystal might be grown if seeded at the proper time (i.e., $BeO:Al_2O_3 \approx 1:1$ near the surface of the melt). When the surface is aluminum rich, the crystal becomes opaque. However, as BeO floats upward, the composition becomes just right for the growth of a transparent crystal on the opaque crystal. But if BeO continues to float upward to form a beryllium rich surface, there is no way for the transparent crystal to continue growing. In order to confirm this hypothesis, we added approximately 1 g of alumina powder to the beryllium rich surface of an aged melt (i.e., a used cold melt not capable of producing transparent crystals). It was verified experimentally that this method could overcome melt aging and produce transparent crystals under certain conditions. Based on this hypothesis, transparent crystals could not be grown if the geometric arrangement in the crucible is altered, i.e., BeO sinters are placed on top of ruby lumps. This was also experimentally verified.

V. Crystal Growth and Testing

1. Crystal Growth

The furnace and its associated apparatus are about the same as reported in previous work [12]. Iridium crucibles and high frequency induction heating are used. Amorphous zirconia was used as a thermal insulator. The protective atmosphere was argon. 2 mm diameter iridium wire was used to pull the crystal out for the first time. Large size single crystals were selected from the polycrystalline block and cut into a-axis crystal seeds in order to grow a-axis crystals. From these crystals b-axis crystal seeds were obtained. Finally, c-axis crystal seeds were obtained by cutting from b-axis crystals. Laser rods were all cut from crystals grown along the c-axis. The maximum crystal size is 20 mm in diameter and 100 mm in length. It could be processed into 5 mm diameter, 91 mm long and 4 mm diameter, 96 mm long laser rods. The crystal could be cut without annealing. We did not observe any cracking. It indicates that there was no high stress in the crystal.

2. Crystal Growth Morphology

The growth rate of alexandrite is apparently anisotropic. It is fastest along the <100> direction and slowest along the <001> direction. Therefore, crystals grown along the a-axis and b-axis are often in the shape of slices. The width to thickness ratio could reach 4:1. Crystals grown along the c-axis may have many shapes, such as a thick plate, elliptical rod or hexagonal rod. The shape is related to the temperature field and growth parameters. Figure 3 shows some frequently seen crystal cross-sections. These cross-sections are similar to those described in the literature [6]. However, the Miller indices in the literature are different from our results. A small 2 mm diameter c-axis rod was cut perpendicular to the <001> face of a b-axis crystal. Its lattice constant was found to be 4.44Å using a revolving x-ray camera, in agreement with the literature value. Two optical techniques were also used in this verification. In addition, the PBC theory used to prove the calculated values was consistent with the experimental ones [15].

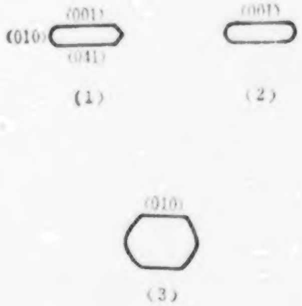

Fig.3 Cross section of alexandrite crystals

(1) —— a-axis crystal, (2) —— b-axis crystal, (3) —— c-axis crystal

3. Crystal Spectroscopy and Laser Experimentation

The fluorescent and absorption spectra of $BeAl_2O_4:Cr^{3+}$ are shown in Figures 4 and 5, respectively. The crystal energy levels of $BeAl_2O_4:Cr^{3+}$ were also calculated from the absorption spectra. The V band of Cr^{3+} was also determined using unpolarized light, as shown in Figure 6. From Figure 4 one sees that the fluorescent intensity in the 750-850 nm range increases with increasing temperature between 50-300°C. Consequently, the lasing property may improve with rising temperature.

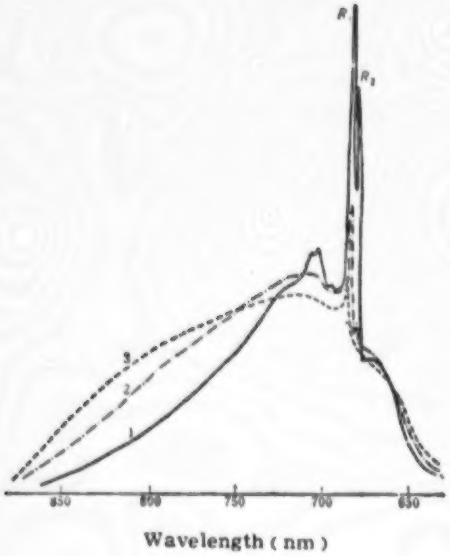

Fig.4 Fluorescent spectra of alexandrite ($E \parallel a$)

1——50°C, 2——200°C, 3——300°C

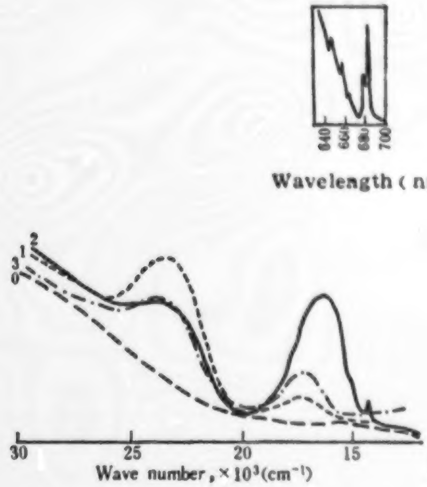

Fig.5 Absorption spectra of alexandrite at 25°C

Figure on the upper-right is a part of the high resolution spectrum

1——$E \parallel a$, 2——$E \parallel b$, 3——$E \parallel c$, 0——Base line

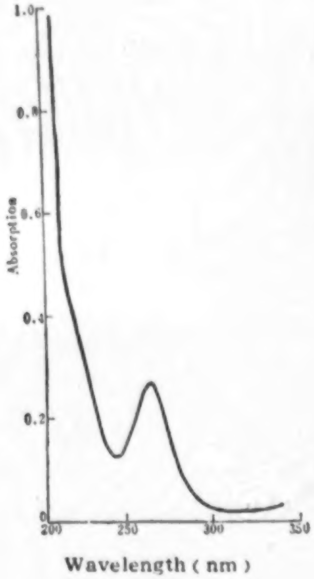

Fig.6 Near ultraviolet absorption band (V band) of alexandrite (without polarizer)

Currently, the $BeAl_2O_4:Cr^{3+}$ laser rod could already lase at 7526Å due to electronic-vibrational transition. The threshold is approximately 90J. Coherent output has already been obtained. Furthermore, the laser output efficiency indeed improved with increasing temperature.

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12553/6091
CSO: 4008/42

APPLIED SCIENCES

ALUMINUM-GRAPHITE COMPOSITE MATERIALS STUDIED

Dalian DALIAN GONGXUEYUAN XUEBAO [JOURNAL OF DALIAN INSTITUTE OF TECHNOLOGY] in Chinese Vol 24 No 3, Sep 85 pp 109-112

[Article by Liang Lida [2733 4539 6671] of the Casting and Research Section of DIT: "An Investigation on the Properties of Cast Aluminum-Graphite Composite Materials"*]

[Text] Abstract: In this work the wear reduction, damping capacity and technical properties of rheocast aluminum-graphite composite materials were tested. The effect of graphite content on various properties was determined to serve as a technical basis for this type of materials.

1. Preparation of Cast Aluminum-Graphite Materials

Al-9%Si-3%Cu-1%Mg was chosen as the matrix of the cast aluminum-graphite material. The particle distribution of the graphite is as follows: 70 mesh 25.5 percent, 100 mesh 12 percent, 120 mesh 26.6 percent, 160 mesh 19.6 percent and >160 mesh 16.6 percent. The aluminum alloy is pre-cast into an ingot and then melted in a ceramic crucible. When the alloy becomes semi-solid (40-60 percent of the alloy is solid), a blending blade pre-heated to approximately 600°C is inserted to stir the alloy. Graphite particles are added while stirring until they are uniformly distributed in the semi-solid aluminum. The fluid is then die cast into the desired shape. This method is called the rheocast method. Graphite particles free of copper and nickel can be used in this method. The technique is simple and easy. Graphite is evenly distributed. The graphite content may be very high. The quality of the aluminum-graphite material is very high, just as in other rheocast processes.

The metallographic structures of aluminum-graphite materials containing various amounts of graphite are shown in Figure 1. In the photograph, we cannot see the nascent α phase tree structure. This type of structure is crushed in the rheological process. The aluminum matrix is composed of nascent α phase and eutectic structure. Graphite particles are mostly in eutectics. A very small amount is in the α phase.

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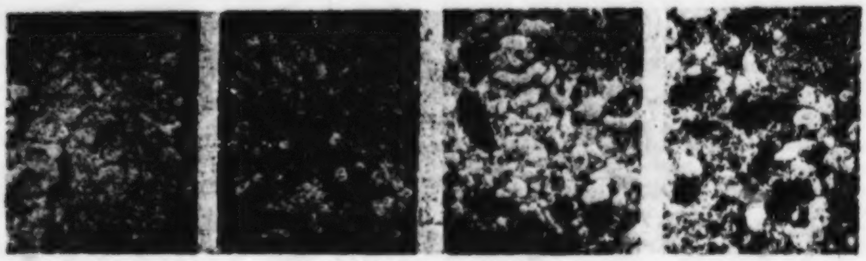
*Manuscript received on 19 October 1984.
Liu Fuyi [0491 4395 5030] also participated in the experimental work.

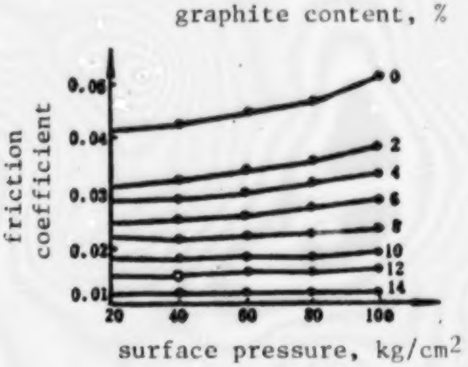


0% graphite 4% graphite 8% graphite 12% graphite

Figure 1. Metallographs of Aluminum-Graphite Materials 100X

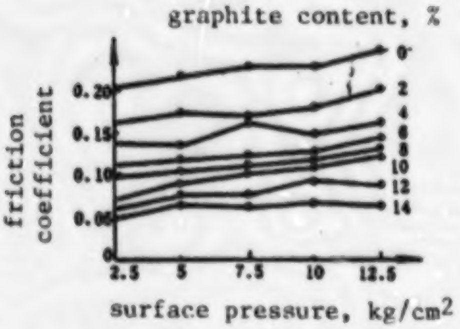
2. Wear Reduction Property of the Material

Materials with various graphite contents were fabricated into friction specimens in order to determine the relation between friction coefficient and pressure under oil lubricated and dry conditions on a frictional wear machine. The results are shown in Figures 2 and 3. The results indicate that the addition of fine graphite particles could lower the friction coefficient in both dry and wet conditions. With increasing graphite content, the magnitude of the drop of friction coefficient also increases.



lubricating condition: oil; rotational speed: 400 r/min;
grinding material: steel

Figure 2. Surface Pressure vs. Friction Coefficient



lubricating condition: dry; rotational speed: 200 r/min;
grinding material: steel

Figure 3. Surface Pressure vs. Friction Coefficient

Based on friction theory we know that a solid lubricant graphite has the following special characteristics:

1. The shear strength of graphite is lower than that of the grinding surface material.

2. Graphite itself has certain adhesion to aluminum and steel.

3. Graphite has an isotropic crystal structure; high compressive strength and low shear strength.

4. The above characteristics do not change significantly with the environment.

Graphite forms a thin lubricating layer between the axle and the bearing. Graphite particles are uniformly distributed in the aluminum alloy matrix. No matter how the worn surface is re-generated, there are always graphite particles on the surface with a self-lubricating effect. The higher the graphite content is, the better the self-lubricating effect becomes and the larger the friction coefficient drops.

3. Damping Capacity of the Material

Various graphite content materials were used to fabricate 1.0 x 10 x 80 mm damping samples. Resistance foil gages were adhered to both sides of the specimen. The strain signal is sent to a dynamic strain meter. It is then amplified and sent into an oscilloscope. One end of the specimen is secured. An activator at a fixed vibration frequency is applied to the cantilever end. After the applied energy is removed, the specimen begins damping. The damping wave is recorded on the oscilloscope to evaluate the damping characteristic of the material by exponential decay. The equation is:

$$Q = \ln(q_k/q_{k+n})/n$$

where Q--natural logarithmic decay rate; n--number of vibration peaks measured; q_k--amplitude of the k^{th} vibration wave; and q_{k+n}--amplitude of the $k+n^{th}$ wave. The natural logarithmic decay rates of materials with various graphite contents are shown in Table 1.

Table 1

Graphite content, %	0	2	4	6	8	10	12	14
Decay rate Q	0.019	0.025	0.030	0.036	0.041	0.045	0.049	0.053

The results show that the higher the graphite content the better the damping characteristics of the material.

Cast iron is a familiar damping material in which graphite is distributed in the steel matrix. The aluminum-graphite material, however, has graphite dispersed in an aluminum matrix. The structures are very similar and their properties must also be similar. The decay rate of cast iron is higher than that of aluminum. The ratio of the decay rate of aluminum-graphite to its density is much larger than that of cast iron. This means that for the same weight, an aluminum-graphite material can absorb more vibrational energy than cast iron. Aluminum-graphite materials can be used to make various damping components in the aeronautic industry and in noise reduction.

4. Remelting of Aluminum-Graphite Materials

An aluminum-graphite material containing 12 percent graphite was placed in a crucible and heated in an electrical furnace. The remelting temperatures are 580°C, 720°C, and 800°C. The temperature was maintained for 30 minutes. Figure 5 shows the longitudinal cross-section of the macro-structure of remelted samples.

The results indicate that the distribution of graphite particles was changed. When the remelting temperature is relatively low, graphite particles are concentrated. However, floating is not serious (see Figure 4.a). When the temperature is too high, the graphite is not concentrated. It, however, generally floats up. The lower part of the sample has a graphite free region (see Figure 4.c). In the region with graphite, it is uniformly dispersed. At 720°C, the graphite behavior is between those at high and low temperatures (see Figure 4.b).

The phenomenon discussed above can be explained as follows: when the remelting temperature is relatively low, thermal convection in liquid aluminum enhances the probability of contact between graphite particles. The surface tension of graphite and that of liquid aluminum are very high. The aggregation of particles in contact can reduce the surface energy, which lowers the total energy of the system. It is very difficult to separate these particles once they become an aggregate. This aggregation, however, is not unlimited. Instead, it is localized. This is how graphite aggregates are created. This effect is related to the weak convection current in liquid aluminum at low temperatures. In this situation, the viscosity of liquid aluminum is very large and the tendency for graphite particles to float upward is very small. Therefore, we did not see a graphite free zone on the bottom of the specimen. When the temperature reaches 800°C, the surface tension of graphite and that of liquid aluminum decrease. The aggregation of several graphite particles cannot significantly lower the free energy of the system. In addition, the vigorous thermal convection of liquid aluminum will separate those graphite particles already aggregated. The viscosity of high temperature liquid aluminum is relatively low, resulting in the floating of graphite. Thus, there is a graphite free area in the lower portion of the sample. The upward floating velocity of a graphite particle obeys Stoke's equation which is related to the dynamic viscosity coefficient of liquid aluminum. With increasing temperature, this coefficient decreases and the upward velocity increases resulting in an increase of upward distance within a fixed time period.

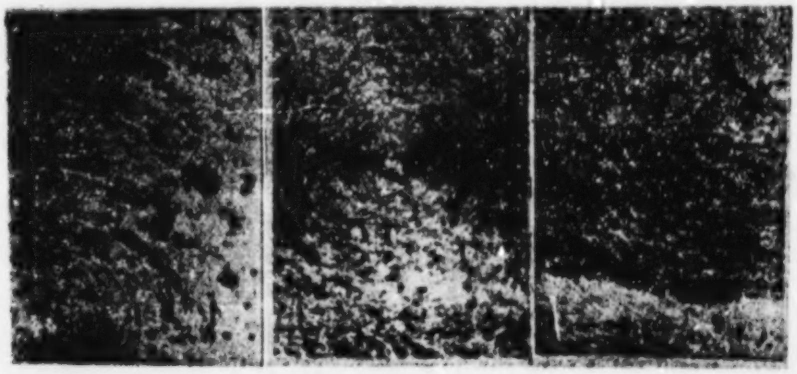

a. 580°C b. 720°C c. 800°C

Figure 4. Effect of Remelting Temperature on Graphite Particle Distribution

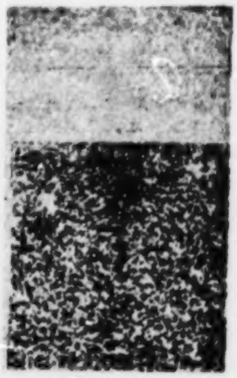


Figure 5. Aluminum-Graphite Containing 35 Percent Graphite X2

Aluminum graphite composite materials with higher graphite contents can be obtained by taking advantage of the phenomenon that graphite particles do not aggregate during remelting at high temperatures. Although they float upward, however, they do not precipitate out of liquid aluminum. A technique was used to remelt an aluminum-graphite material at 820-840°C for 15-20 minutes and then to concentrate them by removing the graphite free part on the bottom of the crucible, resulting in a material containing a graphite content of as high as 35 percent. The macroscopic cross-section of this material is shown in Figure 5.

5. Thioxcast of Aluminum-Graphite Materials

A rheocast aluminum-graphite ingot was heated in an electric furnace. The temperature rising curve of the specimen is shown in Figure 6. The solid phase content at point B was determined to be 35 percent by liquid quench and quantitative metallographic analysis. As the temperature of the specimen rose to point A, the eutectic began to melt. At point B the eutectic component was completely melted and the solid phase was 35 percent. The ingot was cast in a die cast machine. The result showed that the material could form well. An observation of the sample structure revealed that the graphite was dispersed even more uniformly. It is feasible for a plant to use rheocast ingots for die casting to facilitate automated production.

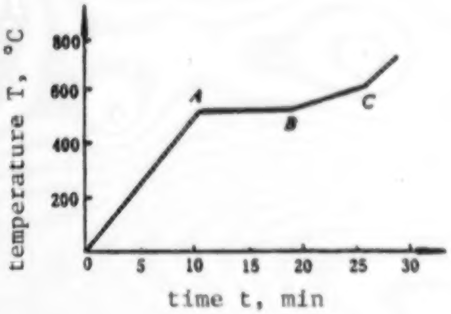


Figure 6. Sample Temperature Rising Curve

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ENVIRONMENTAL QUALITY

WATER RESEARCH HELPS CUT ANTIPOLLUTION COSTS

WO241330 Beijing XINHUA in English 1318 GMT 24 Jan 86

[Text] Beijing, 24 Jan (XINHUA)--Chinese scientists have conducted a survey of the pollutant-assimilating capacity of three rivers, thereby saving for the state 200 million yuan of pollution-control investment.

By analyzing the water of the 200 km section of the Tuojiang River that runs through Sichuan Province, scientists found that the section has the assimilating capacity of 90 tons of organic pollutants every day.

They said that to control the pollution in the river, investment should mainly focus on a chemical plant on the upper reaches of the river and dispose of more than 3,600 tons of the pollutants discharged daily by the plant.

Their results and proposal were accepted by the local government, saving the Province 92 million yuan in investment for pollution control along the river.

After studying an area of over 100 sq km of the Shenzhen River and nearby bay in Guangdong Province, the scientists put forward a suggestion that sewage from Shenzhen city should be discharged to the sea via the Pearl River mouth, reducing the cost of disposal by some 100 million yuan compared to the city's original plan to build 10 sewage treatment plants.

The survey of the section of the Xiangjiang River near Zhuzhou city in Hunan province showed that heavy metal sediment in the river is chemically stable, and the only measure to keep the water quality in line with the standards set by the state is to treat the sewage from the Zhuzhou smelter and other industrial plants.

Water assimilating capacity research, listed as one of the country's major scientific research projects for the sixth five-year plan period (1981-1985), was conducted nationwide by 49 environmental protection units, including the Chinese Academy of Environmental Sciences.

China started research on water assimilating capacity in 1974 and has so far surveyed a dozen rivers. The State Science and Technology Commission has decided to conduct such research into the Pearl River Delta and lakes in the next five years.

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CSO: 4010/1028

ENVIRONMENTAL QUALITY

SHENYANG CITY INTRODUCES SMOKELESS ZONE

OW171154 Beijing XINHUA in English 1145 GMT 17 Jan 86

[Text] Shenyang, 17 Jan (XINHUA)--Fitting industrial boilers with filtering devices and installing domestic central heating systems have proved to be effective steps in eliminating pollution in Shenyang, a major industrial city in northeast China.

The city's 1.5 km Xinghua Street was notorious for the pall of black smoke which used to envelop it all day as a result of the concentration of boilers and coal-burning stoves.

But last year, 86 boilers were fitted with filters and the families in the street now all have central heating.

According to a provincial government official, Liaoning earmarked 740 million yuan for 5,100 environmental protection projects during the Sixth 5-Year Plan (1981-1985). Some 3,278 have already been completed.

Facilities that can threat over 28.3 billion liters of waste water and 50.5 billion standard cubic meters of waste gas a year were built during the plan period.

The official said 11,490 of the province's 29,800 industrial boilers have been fitted with anti-pollution devices.

Last year central heating facilities which are able to provide heat for more than 34,000 square meters of apartments were installed in the city's busy Zhongjie Street, and smoke pollution has been virtually eliminated there.

The provincial environmental protection department said that in the past year Liaoning has set up 20 smokeless zones in other cities such as Dalian, Fushun, Benxi and Liaoyang.

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CSO: 4010/1028

ENVIRONMENTAL QUALITY

TIANJIN ENVIRONMENTAL PROTECTION MAKING HEADWAY

OW031557 Beijing XINHUA in English 1439 GMT 3 Jan 86

[Text] Tianjin, 3 Jan (XINHUA)--Chimneys in a Tianjin electric power plant have stopped emitting black smoke, indicating a major success of this north China industrial center in its effort to control air pollution.

The plant, now being rebuilt into a heat and power plant, used to be one of the city's three major air pollution sources.

Air pollution by other two, a carbon black factory and a steel mill, has also been brought under control, city officials said.

Tianjin spent 264 million yuan on environmental protection during the sixth five year period ending last year, and has so far completed 2,000 projects for that purpose.

While retooling factories to reduce pollution, the city government moved 108 pollution-causing factories out of the city center.

In addition, 300 electroplating workshops were closed down or merged into other factories.

A sewage treatment plant built during the sixth five-year plan period is able to treat one fourth of the city's sewage, thus reducing pollution of the Bohai Sea.

Tianjin residents planted 14 million trees and the green area increased by nearly one million square meters.

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CSO: 4010/1028

ENVIRONMENTAL QUALITY

TIANJIN ESCALATES CAMPAIGN AGAINST AIR POLLUTION

OW181736 Beijing XINHUA in English 1508 GMT 18 Jan 86

[Text] Tianjin, 18 Jan (XINHUA)--Ninety-seven percent of industrial Tianjin's one million families will be cooking with gas by late next year as this coastal city escalates its campaign against air pollution.

Municipal officials said today only 26 percent of the city's families have gas cooking facilities, while the rest use coal stoves.

Wherever possible, they said, the city will help residents buy gas burners fueled by tanks or metered lines.

In addition, the city has begun building a system of centralized heating plants to eliminate coal-fired boilers in factories and heating stoves in residential buildings, according to the officials.

Trees will be planted to help clean the air and separate polluting industrial districts from the neighborhoods where most Tianjin residents live, they said.

The city campaign follows a survey of city pollution conducted by 300 scientists with the help of 7,000 residents.

They said the causes of Tianjin's air pollution must be attacked or, as one put it, "the smog by the end of the century will be as bad as London's at its worst."

The scientists found air problems stemming from burning coal, sandstorms, dirt, building materials and motor vehicle exhaust.

To keep the air clean, they said, the city must radically reduce coal use, isolate industrial areas with greenbelts and improve roads--both to cover dirt streets and to cut vehicle exhaust by improving traffic flow.

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CSO: 4010/1028

ENVIRONMENTAL QUALITY

BRIEFS

XINJIANG ENVIRONMENTAL PROTECTION--During the Sixth 5-year plan period, the region's environmental protection cause developed rapidly. During the period, the region improved environmental pollution in regard to more than 1,800 cases and the total investment in this respect amounted to nearly 80 million yuan. The region has set up 51 installations for the disposal of waste water. Karamay City has invested some 3 billion yuan to build a waste water disposal plant. Some 40,000 vehicle in Urumqi City have been installed with low-volume loudspeakers instead of high-volume ones. Over the past 5 years, the region has built 16 natural environment protection areas, covering an area of some 84,000 square kilometers and accounting for 50 percent of the country's total natural environment protection areas. During the period the region made scientific research achievements in regard to 28 items of environmental protection. [Summary] [Urumqi Xinjiang Regional Service in Mandarin 1300 GMT 15 Jan 86 HK] /9738

FUJIAN ENVIRONMENTAL PROTECTION--Fujian achieved much progress in environmental protection work during the sixth 5-year plan period. Some 600 environmental protection projects were completed throughout the province during the period. Some 630 environmental workers are now working at various levels of environmental administration bureaus in the Province. Starting from scratch, the Province now has 9 plans specializing in manufacturing environmental protection equipment. Six provincial-level nature preserve parks and 2 agriculture preserves were set up in the past 5 years with a total acreage of 1.3 million mu. A total of 1.89 million mu of land was afforested. [Summary] [Fuzhou Fujian Provincial Service in Mandarin 1130 GMT 8 Jan 86 OW] /9738

CSO: 4008/1036

Analytical Chemistry

MASS SPECTRA OF SOME TRIMETHYLSILVYL DERIVATIVES OF PHOSPHONIC AND PHOSPHONOTHIOIC COMPOUNDS

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7, 20 Jul 85 pp 481-484

[English abstract of article by Guo Hangzhou [6753 2635 1558] and Cao Jinhong [2580 6855 7703] of the Academy of Military Medical Science]

[Text] Phosphonic and phosphonothioic acids are hydrolytic products of organophosphorus pesticides. The analysis of phosphonic and phosphonothioic acids is very important in environmental pollution control. Due to the presence of hydrogen bonds they are difficult to volatilize and, therefore, are not suitable for GC-analysis. In this paper a reliable method for derivatization of these compounds is introduced and the mass spectral fragmentation of these derivatives is discussed. (Paper received 4 May 1984.)

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1.5-DERIVATIVE POLAROGRAPHY BASED ON MICROCOMPUTER

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7,
20 Jul 85 pp 484-488

[English abstract of article by Wu Shouguo [0702 1345 0948], Pu Guogang [5543 0948 0474] and Wang Erkang [3076 1422 1660] of the Department of Applied Chemistry, University of Science and Technology of China, Hefei]

[Text] A real-time controlled high-accuracy data acquisition and processing system is described and evaluated. The system is applied to acquire and process the linear sweep voltammetric data of a two-component system with HMDE. The original data is processed first with the 9-point least-square smoothing technique, then with a convolution transform algorithm to obtain semi-integral, semi- and 1.5-derivative polarograms. This neopolarographic method based on a microcomputer is much better at reducing noise interference than that using an electronic analog instrument and can improve the sensitivity and resolution of the analytical method. (Paper received 14 May 1984.)

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MODIFIED SIMPLEX OPTIMIZATION OF $Ar-H_2$ PLASMA EMISSION SPECTROSCOPY

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7, 20 Jul 85 pp 498-503

[English abstract of article by Xu Liqiang [1776 4539 1730] of Shanghai Institute of Metallurgy, Chinese Academy of Sciences; and P. Schramel of the Institute of Applied Physics, Center for Radiation and Environmental Research, FRG]

[Text] This paper describes a method using partial factorial design (orthogonal test) and modified simplex optimization to optimize the operating parameters of an $Ar-H_2$ plasma, including observation height, power, flow rates of carrier $Ar+H_2$, auxiliary $Ar+H_2$, coolant $Ar+H_2$, to obtain maximum signal-to-background ratio. The block diagram of the microcomputer calculation is presented. The operating parameters for 14 elements are investigated by simultaneous ICP-AES and grouped according to the behaviors in such plasma. The detection limits of Cd, Fe, Cr, Be, Ni and V have been improved under the optimal operating parameters for Ca, which were recommended as compromise operating parameters for multielement analysis. (Paper received 18 June 1984.)

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STUDY OF THE EFFECT OF MIXED IONIC-NONIONIC SURFACTANTS ON COLOR REACTION AND ITS APPLICATION. II. THE INFLUENCE OF REACTION MICROENVIRONMENT ON SYNERGIC SENSITIZING EFFECT

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7, 20 Jul 85 pp 506-510

[English abstract of article by Qi Wenbin [2058 2429 1755] and Zhu Lizhong [2612 0448 0022] of the Department of Chemistry, Hangzhou University]

[Text] The formation of mixed micelle has been considered to be a main cause of the synergic sensitizing effect of mixed ionic-nonionic surfactants on color reactions. The effect of a surfactant mixture of CTMAB-Peregal O on both Cd-PAR and Al-CAS has been investigated in detail. The formation of mixed micelle has been further proved by surface tensions of the color systems. It may change such aspects of the microenvironment as the dielectric constant, electrical conductivity and the surface activity of color reaction systems. Moreover, some characteristics of color reactions, such as a change in the color reagent pK_a and the formation of higher ligand complexes, may be influences by the mixed surfactants. (Paper received 1 September 1984.)

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CHEMILUMINESCENCE IN ENVIRONMENTAL ANALYSIS. II. DETERMINATION OF MANGANESE(II) IN MINERAL AND POLLUTED WATERS

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7, 20 Jul 85 pp 510-514

[English abstract of article by Zheng Zhuzi [6774 2612 2737] and Wang Zunben [3769 1415 2609] of Xiamen University Chemistry Department]

[Text] Based on the catalytic action of trace manganese (II) on the oxidation of luminol in an alkaline medium, a chemiluminous method for the determination of manganese (II) in mineral and polluted waters has been developed with a luminous analyzer designed by the author. During the progress of the reaction, a light of definite wavelength is emitted, and its intensity is in proportion to the content of the manganese (II). This method is simple and quick. Its sensitivity is high and the detection limit is less than 1.0 ppb. The linear range is obtained from 1 x 10^{-9} to 5 x 10^{-6} g/ml and the reproducibility is good. The analytical results are satisfactory. (Paper received 2 September 1984.)

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CHRAMOTOGRAPHIC ANALYSIS OF HEAVY WATER VIA IRON POWDER CONVERSION METHOD

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7,
20 Jul 85 pp 521-523

[English abstract of article by Li Shutang [2621 2885 1016] of Plant No 4400,
Xianyang]

[Text] In this method the iron powder should be activated before use. During the analysis the water sample will react with activated iron at 700°C to produce H_2, then the deuterium content in the resultant H_2 is measured by chromatography to obtain the D_2O concentration in the water sample. This method is characterized by safety, simplicity, less trouble, low cost of analysis and it is harmless to the operators. (Paper received 14 March 1984.)

DETERMINATION OF TUNGSTEN, MANGANESE, IRON AND NIOBIUM IN PURE TUNGSTEN MINERAL AND TUNGSTEN ORES USING X-RAY FLUORESCENCE SPECTROMETRY

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7,
20 Jul 85 pp 542-544

[English abstract of article by Chen Pitong [7115 0012 6639] of Tianjin Institute of Geology, Ministry of Metallurgical Industry]

[Text] The sample is fused with lithium tetraborate and lithium bromide at 1050-1100°C in a platinum/5 percent gold crucible. Barium nitrate is added to the fusion mixture to act as a heavy absorber and an oxidizing atmosphere is maintained in the crucible during the early stage of fusion. Tantalum pentaoxide is added to the fusion mixture as an internal standard of tungsten. The accuracy and precision of the method are as good as those of the classical chemical method. (Paper received 18 May 1984.)

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A SIMPLE SINGLE CHANNEL FLOW INJECTION SPECTROPHOTOMETER

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7,
20 Jul 85 pp 545-548

[English abstract of article by Lu Yinzhong [0712 6892 1813] and Zhu Yongxuan [2612 0737 3551], et al., of the Institute of Geochemistry, Chinese Academy of Sciences, Guiyang]

[Text] A simple single channel flow injection spectrophotometer, consisting of a Mariot container (as the reagent reservoir and carry flow propeller), rotary sampling valve, PVC thin tube and micro flow through cell, has been developed. Its performance can meet the requirements of simple flow injection analysis. It has been applied to the determination of titanium and iron in standard rock samples. The results obtained are in agreement with the recommended values. The relative standard deviation of the determination is less than 4 percent. (Paper received 28 June 1984.)

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Electronics

SELF-CALIBRATION METHODS OF SIX-PORT REFLECTOMETER

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 8-12

[English abstract of article by Zhou Xuesong [0719 7185 2646] of Chengdu Institute of Radio Engineering, Chengdu]

[Text] Based on the fundamental principle of the six-port circuit, two self-calibration equations derived from the system equations are presented. Several self-calibration methods are discussed by means of the optimum method. The resulting set of computer simulation and measurement on a six-port reflectometer shows that significant improvements in both error cancellation and self-calibration speed are obtained. (Paper received in June 1984; finalized in October 1984.)

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A CAD ANALYTICAL METHOD AND CORRESPONDING PROGRAM FOR MICROWAVE FET NONLINEAR CIRCUITS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 13-19

[English abstract of article by Li Zhengfan [2621 1767 1581] of Shanghai Jiaotong University]

[Text] A CAD analytical method and its corresponding program for microwave FET nonlinear circuits are described. The contents include the nonlinear modeling of MESFET's, a quick convergence method for obtaining the steady state response of nonlinear state equations and a computing program. The CAD method and program can be delivered to resolve various microwave FET nonlinear circuits--multiplier, mixer, large signal amplifier, generator, etc. The results of the FET mixer using this method are given here as an example. (Paper received in June 1984; finalized in September 1984.)

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A MONOLITHIC INTEGRATED PIEZORESISTIVE PRESSURE TRANSDUCER

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 39-44

[English abstract of article by Wu Xianpin [0702 2009 1627] and Bao Minhang [7637 2404 2635] of Fudan University, Shanghai]

[Text] An integrated circuit pressure transducer consisting of a full bridge of piezoresistors with a novel design and an amplifier with temperature compensation is described. The configuration and dimensions of the (100) rectangular Si diaphragm as well as the locations and dimensions of the resistors are optimized through careful computation. The temperature coefficient of the whole circuit is analyzed and minimized. The design has been implemented by conventional bipolar IC technology and anisotropic chemical etching. The transducers fabricated show a sensitivity of about 1000 V/mmHg and have been used for physiological pressure measurement in clinical applications. (Paper received in September 1983; finalized in June 1984.)

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A METHOD FOR IDENTIFYING GYROTRON OUTPUT MODE COMPOSITIONS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 45-50

[English abstract of article by Zhang Zexiang [1728 3419 3276] of the Institute of Physics, Chinese Academy of Sciences, Beijing]

[Text] The identification of mode compositions of gyrotron output power is discussed using far-field radiation pattern analysis. A general analytical method and a simple experimental approach are given. The suggested method can also be used for measuring high power mode-conversion oversized waveguides.
(Paper received in March 1984; finalized in June 1984.)

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ON CURVED ELECTRON BEAMS IN CROSSED ELECTRIC AND MAGNETIC FIELDS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5,
Sep 85 pp 51-58

[English abstract of article by Ni Zhijun [0242 3112 6874] of Chengdu Institute of Radio Engineering]

[Text] According to the synthesis of the formation of electron beams, general solutions for space-charge flow and electrode shape are derived in a crossed electric and magnetic field electrode system in which the cathode operates under arbitrary conditions. Characteristics of some magnetron injection guns and crossed-field guns, based on the general solutions, are calculated and analyzed. The effects of the cathode surface electrid field intensity and electron initial velocity on electron trajectories and electrode shapes are discussed. (Paper received in January 1984; finalized in October 1984.)

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ON DYADIC GREEN'S FUNCTIONS IN SPHERICAL COORDINATES IN FREE SPACE

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 83-91

[English abstract of article by Pan Shenggen [3382 3932 2704] of Shanghai University of Science and Technology]

[Text] The dyadic Green's functions in spherical coordinates in free space are derived by the methods of $\overline{G}_A$, $\overline{G}_m$ and $\overline{G}_e^0$, and a systematic investigation is made of the general properties of the dyadic Green's functions at the source region. Ambiguities associated with dyadic operation in the literature are clarified and some errors are redressed.

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Nuclear Power Engineering

STRESS-CORROSION BEHAVIOR IN WATER MEDIA CONTAINING CHLORINE OF THE BRAZING JOINT OF GRIDS FOR PRESSURIZED WATER REACTOR FUEL ELEMENT

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 14-17

[English abstract of article by Zhang Weijie [1728 4850 2638] and Li Wenqing [2621 2429 3237]]

[Text] This paper details the testing results of the stress-corrosion behavior in 150°C water media containing chlorine for the brazing joints made from three alloy systems, Ni-Cr-Si, Ni-Cr-P and Ni-P, including 16 compositions. The test results indicate that, in the Ni-Cr-Si system, the Ni-Cr-Si-Ge brazing joint is the best for resisting stress-corrosion, while Ni-Cr-Si-P-Ge, Ni-Cr-Si-P-Ge-Pd and BNi5 brazing joints are fairly good. In the Ni-Cr-P system, only the Ni-Cr-P-Mo-Zr brazing joint has good resistance to stress-corrosion.

BERYLLIUM USED IN HFETR

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 18-24

[English abstract of article by Shi Jingxian [2168 2529 6343] and Xu Jiangqing [1776 3068 3237]]

[Text] This paper presents the design characteristics of the beryllium assembly used in a High Flux Engineering Test Reactor (HFETR) and gives some results of physical calculations for some physical problems of the reactor core which contains beryllium, e.g., the poison build-up in the beryllium reflector, etc.

MEASUREMENT OF SOURCE TRANSFER FUNCTION AND SPACE DEPENDENCE USING PULSED NEUTRON SOURCE ON BERYLLIUM-LIGHT WATER LATTICE

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 25-31

[English abstract of article by Peng Feng [1756 7685], Xie Jingwen [6200 2529 2429] and Wu Baoan [0702 1405 1344]]

[Text] This paper describes an on-line pulsed neutron source experiment on beryllium-light water lattice. Pulsed neutron source transfer functions are given. A space-dependent prompt neutron decay constant α has been found are results are discussed.

APPROACH OF DECONTAMINATION PERFORMANCE FOR THE EVAPORATING SYSTEM IN THE RADIOACTIVE WASTE TREATMENT FACILITIES OF HIGH FLUX ENGINEERING TEST REACTOR

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 32-37

[English abstract of article by Hu Zhenqian [5170 2182 0051]]

[Text] This report presents the removal of radioactive components from radioactive liquid waste by an evaporator, a cyclone and a demister and, in addition, describes the interrelationships of radioactive decontamination with mass velocity and the concentrating factor. Based on data obtained by the site equipment, the interrelationships are summarized as simple mathematical formulae. The paper also indicates that the demineralization characteristic can be applied to explain radioactive decontamination performance for an evaporator.

THE FLUX-LIMITED ASYMPTOTIC DIFFUSION THEORY

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 51-58

[English abstract of article by Liu Chengan [0491 2052 1344]]

[Text] In order to eliminate the classical diffusion theory's limitations on describing transport problems, the multigroup asymptotic diffusion equation and appropriate flux-limited methods have been derived from a special form of the angular distribution flux. For the scattering medium, the flux-limited asymptotic diffusion theory is in semiquantitative agreement with the various typical flux-limited diffusion theories. For the absorbing medium and multiplying medium, precision is presented by the asymptotic diffusion theory. It retains the simplicity and convenience of the classicial diffusion theory, but improves the precision in describing transport problems.

TRANSPORT EFFECT FOR CONTROL ROD CALCULATION

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 59-69, 76

[English abstract of article by Ma Dayuan [7456 1129 0954] and A. D'angelo]

[Text] Transport mesh-effect and transport effect for control rod calculation have been studied. The numerical results show that the mesh-size effect of transport calculation is small (approximately 30 percent or less of the corresponding diffusion calculation) and is of the opposite sign for mesh-centered flux diffusion calculations. The results also show that the axial transport effect, which has been neglected before, does exist, although it is very small and has the opposite sign of the horizontal transport effect. This means the control rod value is underestimated in the vertical direction by diffusion theory. In this paper, a simple method for treating the axial transport effect is discussed. The numerical results using this method are very close to the results of the reference method. The method presented in this paper is useful for getting an approximate result for a three-dimensional transport calculation.

AN ACCURATE TREATMENT OF ELASTIC SCATTERING IN LIGHT AND MEDIUM ELEMENTS IN FAST REACTORS

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 70-76

[English abstract of article by Li Zehua [2621 3419 5478] and Zhou Zhennian [0719 2182 1628]]

[Text] In this paper the newer data have been used for making multigroup accurate treatment of elastic scattering in light and medium elements in fast reactors in which the resonance treatment is more careful. A total of 491 resonance peaks, including Na, Fe, Cr and Ni elements, is calculated, and the contribution from the P wave is also considered.

Through the calculation the neutron spectrum is given for the normal fast experiment reactor core and a mock-up core with 50 percent of the normal Na density. This will be useful for fast reactor safety analysis.

DETERMINATION OF PLUTONIUM IN $Pu(SO_4)_2 \cdot 4H_2O$ BY CONTROLLED-POTENTIAL COULOMETRY

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 77-79, 86

[English abstract of article by Sun Wenhao [1327 2429 6275]]

[Text] In this paper a method for the determination of the plutonium in $Pu(SO_4)_2 \cdot 4H_2O$ by Controlled-Potential Coulometry is presented. The precision for determining about 3 mg is better than 0.1 percent. The results obtained by this method are compared with others, and it is proved to be precise and accurate.

PERFORMANCE MEASUREMENT OF ^{60}Co TELETHERAPY SOURCE IN EQUIPMENT AT USERS

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 80-86

[English abstract of article by Li Xingyuan [2621 2502 0997], Chen Zigen [7115 1311 2704], et al.]

[Text] The main circular performance of a high activity ^{60}Co teletherapy source made in China for the first time is measured by a few methods after having been fitted in equipment at the users' sites. The results obtained provide useful parameters for production and application of the ^{60}Co teletherapy source.

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Organic Chemistry

CRYSTAL STRUCTURE AND ELECTRONIC STRUCTURE OF cis-BIS(CHLOROACETATO)-2,3-DIMETHYL-2,3-BUTANEDIAMINOPLATINUM

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 43 No 6, Jun 85 pp 507-513

[English abstract of article by Qu Yun [2575 4596] and Tang Wenxia [0681 7186 7209], et al., of the Institute of Coordination Chemistry, Nanjing University; and Wang Fengshan [3769 7364 1472], et al., of the Department of Chemistry, Jilin University, Changchun]

[Text] The title compound was crystallized in space group $P2_12_12_1$ with unit cell constants, a = 9.866(4)Å, b = 16.356(2)Å, c = 19.501(4)Å, $\alpha = \beta = \gamma = 90°$, and Z = 8. The intensities were collected with a Nicolet-R3 four-circle diffractometer. The Pt atom coordinates were derived from Patterson's function. The parameters of the other atoms were found from successive Fourier and difference Fourier syntheses. The block-diagonal least squares refinement for all atoms gave a final discrepancy factor R = 0.061. The results obtained showed that the title compound was a square planar complex with a diamine chelate ring conformation, and that the bond angle of O-Pt-O is equal to about 80°, much smaller than the corresponding value in other Pt complexes.

The electronic structure of the title compound was calculated by the CNDO/2 method. The unusual bond angle of O-Py-O and the relationship between the structure and antitumor function are discussed. (Paper received 23 December 1983, and finalized 12 November 1984.)

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STUDIES OF o-HYDROXYBENZYLAMINE-N, N, O-TRIACETIC ACID (HBATA) AND ITS COMPLEXES. II. CHELATES OF YTTRIUM AND YTTERBIUM

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 43 No 6, Jun 85
pp 562-565

[English abstract of article by Zhang Hualin [1728 5478 7792] and Xu Kangcheng [1776 2123 2052] of the Department of Chemistry, Fudan University, Shanghai]

[Text] The stability constants of HBATA with Y(III) and Yb(III) were determined pH-metrically in aqueous solution at 30.0 ± 0.1°C in the presence of 0.1M potassium nitrate, with log k_1 being 9.55 for Y(III) and 10.73 for Yb(III). $ML \cdot 3H_2O$ (M = Y or Yb, L = HBATA) was prepared and characterized by elemental analyses, molar conductance, magnetic moment and infrared spectra studies. The thermal decomposition of the Y(III) chelate was studied by TG, DTG and DTA techniques. The results indicate that the ether-bonded oxygen atom in HBATA is coordinated to the metal in these chelates, therefore HBATA acts as a quinqhedentate ligand and the coordination number of Y(III) may possibly be eight. (Paper received 24 April 1984.)

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Physical Chemistry

THERMODYNAMICS OF MULTICOMPONENT ELECTROLYTE SOLUTIONS. II. ACTIVITY COEFFICIENT FOR THE SYSTEM $HCl-CoCl_2-H_2O$ AT 298.15K

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 43 No 6, Jun 85 pp 557-561

[English abstract of article by Chu Mingchen [0443 2494 2525], Liang Chunyu [2733 2504 0151] and Yang Jiazhen [2799 1367 2182] of the Department of Chemistry, Liaoning University, Shenyang]

[Text] Activity coefficients for HCl in the system $HCl-CoCl_2-H_2O$ at 298.15K and at constant total ionic strengths of 0.1, 0.5, 1.0, 2.0, 3.0, 4.0 and 5.0 $mol \cdot kg^{-1}$ have been measured by the EMF method. The results have been treated using Harned's and Pitzer's equations for mixed electrolyte solutions. The results show that HCl follows Harned's Rule at constant total ionic strength from 0.1 to 5.0 $mol \cdot kg^{-1}$ at 298.15K. The mixing parameters θ and ψ have been obtained by using three methods and activity coefficients for the salt $CoCl_2$ have been derived. The results obtained by the three methods are in agreement within experimental error. (Paper received 27 March 1984.)

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SCIENCE AND TECHNOLOGY

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'SPARK PLAN' PROJECTS OFF TO QUICK START

Tianjin JISHU SHICHANG BAO in Chinese 17 Dec 85 p 1

[Article by Zhu Qingfang [2612 1987 5364]: "'Spark Plan' Projects Satisfy Urgent Rural Need for Scientific Know-how"]

[Text] The implementation of the "Spark Plan," approved by the State Council, is in full swing at present. As of late November, 40 projects involving state investments have been planned. Provinces, autonomous regions and municipalities directly administered by the central government are also working out their own "Spark Plans."

Reports suggest that "Spark Plan" projects have been able to get off the ground so quickly because, first, they are oriented toward rural and township enterprises and villages. They adapt to the technical standard of these enterprises and tackle the right kind of technology. The "Spark Plan" will be the engine which powers the technical modernization of rural, township, small and medium-sized enterprises and helps the vitalization of local economies. Second, "Spark Plan" projects focus on aquaculture, the fast breeding of poultry and waterfowl, the production of livestock products derived from herbivores, the processing and use of agricultural products, rural construction and the development of related products. They make full use of all kinds of local resources and do not compete with large enterprises for energy and raw materials. Third, "Spark Plan" projects are selected with consideration for an array of factors like market, raw materials, technological standard and pollution prevention. Projects also come with measures to manage investment and the import of technology, providing the ideal conditions for their implementation.

The proposal and realization of the "Spark Plan" have caught the attention and interest of leading comrades on the CPC Central Committee. Recently Vice Premier Wan Li said, "Villages and townships have a crying need for science and technology. Today it is the countryside which shows the greatest enthusiasm for scientific and technical knowledge. People there urgently need to improve labor productivity, produce more products, shake off poverty and become well off. We must channel science and technology toward the villages through reform. That way, not only will rural and township enterprises thrive, but agriculture will also be able to do much better." He also said, "The 'Spark Plan' is well conceived, something the masses of peasants badly need. It is a vast world out there where much can be accomplished. You must work hard and hang in there for a couple of years. Success is a foregone conclusion."

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'SPARK PLAN' DELIVERS SCIENCE, TECHNOLOGY TO COUNTRYSIDE

Tianjin JISHU SHICHANG BAO in Chinese 17 Dec 85 p 1

[Article by Cheng Yinsheng [2052 6892 3932]: "'Spark Plan' Projects Will Set the Countryside Ablaze With Technology"]

[Text] The "Spark Plan" has attracted the attention of people from all walks of life because it aims at delivering science and technology to the vast countryside and myriad townships and contributes to the development of rural and township enterprises and the vitalization of local economies. It completely conforms to the trend of scientific and technical reform and satisfies the demands which the goals of national economic development make on scientific and technical work during the "Seventh 5-Year plan" period.

Since the 3d Plenary Session of the 11th CPC Central Committee, the situation in the countryside has been getting better and better. But because of our weak agricultural base, peasants in some areas still do not have enough to eat or wear. The masses of peasants fervently hope to increase labor productivity and create more wealth so as to eradicate poverty. Following the development of rural commodity production in recent years, peasants have grown keenly aware of the lack of expertise, technology and qualified personnel in the countryside. They became convinced that the vitalization of the rural economy depends on first, policy, and second, science and technology. The "Spark Plan" is exactly an exploration and experiment in the combination of policy, on the one hand, and science and technology, on the other. Moreover, it coincides with the urgent desire of countless peasants for science and technology. The implementation of this plan will be the spark setting the countryside ablaze and deliver to rural and township enterprises the key to the door of development.

Setting the Countryside Ablaze Requires Igniters

To increase rural labor productivity by an appreciable extent and kindle the fire of modernization in the vast countryside, a crucial step is to train a group of grassroots cadres and high school graduates. As things now stand, our grassroots cadres lack training in modern social management and science and technology, while our numerous high school graduates, though bursting with youthful vitality, have no professional, scientific or technical training. To set the countryside ablaze, we need people to fan the fire. If we give grassroots and high school graduates just a modicum of training and equip them with a skill or two, they can certainly make themselves useful in the magnificent undertaking of rural modernization. Besides attracting over 100 qualified people to the county, the Science and Technology Commission of Hengdong County, Hunan, organized 30 technical training courses in the second half of this year and trained more than 3,000 people, which enabled the county's rural and township enterprises to increase output value by 1 million yuan. Then there are localities which make full use of all manner of professional schools, institutions of higher education and research institutes to turn out qualified technical personnel for rural and township enterprises.

Development Projects Chosen With An Eye To Local Circumstances

The point of departure for the "Spark Plan" is the coordination of the economic, social and environmental results of rural development. The purpose is to base the technical advancement of rural enterprises squarely on agricultural development. A total of 14 technical fields have been selected for priority development this year and next. Conditions in China's countryside vary considerably. Each locality has its own personality and special circumstances, so science and technology in the countryside must be individualized. In selecting development projects, we must carefully consider the local conditions and possibilities. Successful projects in such fields as breeding, processing of agricultural products, mountain area development and building materials can be expected to have a positive effect on the locality's economic take-off.

Hard Work Needed To Develop Own Technical Capability

It is in technology that qualified personnel and projects come together. The significance of the "Spark Plan" lies in the encouragement it gives to villages and townships through demonstration to develop their own technical prowess from practice in order to facilitate their further growth. Analyzing the overall situation, we see that villages and townships do take the import of technology from other parts of the country seriously, use the import to propel their own technical advancement and work hard to develop their own technical capability. Right now there are over 200 rural and township enterprises in Shanghai which are shifting from labor-intensive operations to technology-intensive ones. Such technologies as duct forming equipment, clothing buttonhole lockstitcher, and plastics molding press have all been channelled toward rural and township enterprises. About a dozen agricultural technologies, including the cultivation of quick-ripening oranges and tangerines and fish-breeding in paddy fields have breathed life into and invigorated the villages in Ling County, Hunan.

Transfer Technology To The Countryside Through the Technical Market

At present, technical markets are thriving everywhere. The full use of such markets to facilitate the transfer of technology to the villages and townships is an pioneering journey on which various localities have embarked, charting their own road map. The Hebei Provincial Science and Technology Commission has demanded that municipal and county technical markets provide rural and township enterprises with information through various channels and in different ways; assist villages import technology and recruit qualified personnel; and offer them a full range of technical services. To promote the development of rural and township enterprises, the Science and Technology Commission of Foshan County, Guangdong, gives priority to the implementation of projects with a short turnover time which require little capital and produce quick results. By acting as a go-between, it has opened the door through which technology can enter the countryside.

It is a foregone conclusion that through the concerted efforts of people in all trades and at all levels, a single spark can set the entire countryside ablaze.

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TECHNOLOGY IMPORTS BEGIN TO PAY OFF

Beijing RENMIN RIBAO in Chinese 14 Jan 86 p 2

[Text] According to comrades from localities and departments which took part in the national economic work conference, the technology we imported in the "Sixth 5-Year Plan" has begun to pay off.

During those 5 years, the state, localities and departments imported from abroad about 14,000 items of advanced technology, of which the bulk were used to modernize small and medium-sized enterprises. Both practical and modern, many of them were bought, installed and went into operation the same year.

The experience of various localities proves that after delivery and put into production, these technologies have begun to pay off in the following four ways:

1. a good return on investment. They are earning and saving foreign exchange for the state. According to an analysis of imports which have been put into service in Beijing, Shanghai and Tianjin, output value rises by 2.5 yuan to 2.8 yuan and profit tax by 0.5 yuan to 0.8 yuan for every yuan invested. The entire investment can be recouped in 2 or 3 years.

2. speeding up product renewal and succession, filling a technical vacuum in the national economy and promoting the development of new materials. In recent years, the machinery industry has imported over 500 pieces of technology, accelerated product renewal and succession, filled some technical gaps in the nation and pushed some 5,000 products to the level of the late 1970's and early 80's.

3. promoting absorption and the substitution of foreign products with domestic ones. From test manufacturing single pieces of machinery, we are now beginning to make whole plants.

4. Technology import has furnished enterprises with qualified personnel, technology, equipment and managerial experience and speeded up their technical modernization and reorganization.

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REFORM OF SCIENCE, TECHNOLOGY PLANNING MANAGEMENT SYSTEM

Jinan DAZHONG RIBAO in Chinese 6 Nov 85 p 4

[Article by Zhang Junhua [1728 0193 5478]: "Major Issues in Reforming the Science and Technology Planning Management System"]

[Text] Reforming the science and technology planning management system is an important part of implementing the CPC Central Committee's resolution on restructuring the science and technology system. In this connection, the following issues merit our special attention:

(1) Science and technology development planning and national economic planning must proceed in tandem. Generally speaking, science and technology can be transformed into material economic capability through popularization and application. The development of such a capability, in turn, is bound to influence science and technology by posing it with new research topics which, ultimately, will lead to further economic growth. For this reason, science and technology planning and economic development planning should be integrated and considered in a broad context, instead of being confined to watertight compartments. Specifically we should set up a guiding agency for comprehensive planning whose responsibility will be to draw up a general planning outline. The various departments in charge will then formulate plans for their own subordinate bodies under the guidance of the general planning outline. Finally the departments should come together to harmonize and finalize their plans through analyses, justifications and revisions.

(2) The coexistence of guidance planning and command planning in science and technology. Like the socialist economic planning system, the science and technology planning system should embody both unity and flexibility and manifest itself as guidance planning as well as command planning. Years of practice shows that the exclusive reliance on command planning led to overcentralization, the result of which is that the state became overburdened while many counties and municipalities had no projects to work on. Also, it led to such negative tendencies as level after level ignoring what was key technology in the localities and emphasizing what they called "advanced, feasible and rational," resulting in a single-minded pursuit of "high-grade, precision and advanced products." In formulating their science and technology plans, therefore, all levels should combine projects in the command plan, which are vital and have overall significance, with projects in the guidance plan, which benefit local development as well having broad significance.

(3) Matching science and technology investments by the state with science and technology investments by localities. One way to influence science and technology planning is through investment. Traditionally, local investments in science and technology bore no relationship to national economic growth or to local budgetary conditions. The state was the only funding agency for science and technology and direct appropriation the only funding method. Investments were simply spent and not required to be paid back. All this put a ceiling on the number of projects we could undertake and made for inferior science research conditions. As a result, science and technology development was stunted. The present effort to alter this situation revolves around the reform of the funding system. Even as we adopt a system of classified management for science and technology funds, we must also proceed to match state investments with local investments, establishment local technology development funds and increase local contritutions using a variety of channels, approaches and methods so that state and local investments will come to depend on, relate to and interact with each other. Localities in the Huimin area, for instance, set aside a portion of their revenues to help counties and municipalities establish technology development funds. Regulations were also drawn up stipulating that counties and municipalities will receive appropriations only after dipping into their own science and technology development funds. The result is that overall science and technology appropriations in that area rose 8.7-fold over a year ago.

(4) Simultaneous management of science and technology funds by science departments and banks. It works this way. The science department is responsible for the overall supervision of a particular project while the bank oversees and manages the way the funds are spent throughout the project. This system of dual supervision goes into effect after the three parties--the science department, the unit which undertakes to do the project, and the bank--have signed an agreement. Its advantages are that economic mechanisms can be used to tighten financial management discipline and investments are used to the full. It also facilitates the recoupment of capital.

(5) The compensatory contract system and the project contracting system can proceed side by side. Under the former system, after determining whether the costs of a project are to be repaid in part or in full, the parties concerned also spell out clearly the contents of the project, its goals, the responsibility of each party involved, reasonable rewards and penalties, and the date by which the funds should be repaid. Under the latter system, only the responsibilities, rights and interests of scientific research personnel are clearly specified. These two systems exert pressure on the unit which undertakes to do a project and the project group, but they also inject into them a measure of vitality.

(6) Science and technology planning should be better coordinated. At present there is no coordination between functional departments at various levels. Say a department wants to increase science and technology appropriations, a request, however, which may not end up in the budget. Another department may want subordinate agencies at the lower level to increase science and technology investments only to be thwarted by the finance department at the same level saying that the lower agencies have not got their accounts right.

This lack of coordination is due to a multitude of factors. Therefore, we should work out measures in a coordinated way so that the science and technology policies of the localities can take into account local conditions and remain flexible without violating the policies of the higher authorities.

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NATIONAL DEVELOPMENTS

PLANS FOR REFORM OF ALLOCATION SYSTEM DISCUSSED

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENTIOLOGY AND MANAGEMENT OF S&T] in Chinese No 10, 12 Oct 85 pp 19-21

[Article by Sang Yiye [2718 0001 0673], Dalian Municipal Science Education Committee: "A Discussion On the Restructuring of the Allocation System"]

[Text] Restructuring the science and technology funds allocation system is a key link in the restructuring of the science and technology system. Beginning last year, more than half the industrial development and applications research organizations in the city of Dalian undertook an elimination of operating expenses and implementation of a compensated contract system. By the beginning of 1987, operating expenses for this kind of research organization will be completely eliminated throughout the city. But elimination of the operating expenses for research units is not the extent of reforms of the allocation system. Having changed the old allocation methods, how are we to set up a new allocation system? On top of putting money into science and technology funds, how are we to change the decision making procedures that are the wills of senior officials and of departments and establish scientific decision making procedures? If we eliminate operating expenses based research organizations, how will there be income and how will they develop their services? In sum, how will we establish a set of operational regulations for science and technology that are even more closely integrated with economic construction? In the reform of the allocation system, these are problems that must be earnestly resolved from the point of actual work to that of ideological concepts.

There have generally been two ways to obtain scientific research funds for development and applications research organizations. One is operating expenses provided by the state, which is also called per capita fees; the other is from the three types of scientific and technical expenses allocated by the state, which includes various levels of government, and which is also called project expenses. Research units report their plans to superiors, list the projects, and when they have been arranged in order, the higher authorities then allocate funds. This kind of allocation for scientific and technical funding is called by some people "eating the public grain."

Where is the abuse in "eating the public grain?" One, because when units engaged in development and applications research "eat the public grain," they are ensured of a steady income despite conditions, and they lack an internal sense of urgency and of crisis for problems that exist in development, and their sense of competition is weak. They only have enthusiasm for dealing with funding units, have enthusiasm only for higher authorities, and lack any pressure to cater to economic construction. Therefore, if economic results are not respected in research organizations, and they do not pay close attention to technical matters in need of urgent solution that appear in production and actual practice, then there is a serious tendency to favor papers and high-precision technology. Two, the field of vision for science and technology management departments is not wide, and they can in general only select the objects of funding from among units applying for projects; this means that units are always competing on the basis of the enthusiasm that comes from competing for projects, and they neglect the needs of economic construction for those projects and do not take seriously developing competition along the lines of research capacity. The result of all this is that the stronger projects needed in economic construction cannot necessarily be chosen, nor will those units with greater research capacity necessarily be given an opportunity; scientific research projects are fragmented and dispersed, and the focal points are not prominent. Three, because state financial abilities are limited, investment in scientific and technical service cannot satisfy the needs of science and technology research. Since research organizations are used to eating from the "public grain," they cannot eat less, so many research organizations and scientists and technicians that have had little or no tasking for quite some time have no enthusiasm nor pressure for finding tasking within economic construction; because of the limitations of departments with talent, those scientists and technicians who have no tasking cannot take up other work. This has given rise to a serious waste of technology, knowledge, and talent. Four, because research units have "eaten the public grain," the rights to scientific and technical achievements are transferred without compensation, and scientific and technical funds are used without compensation, which has for a long time been an important factor in the inability to commercialize scientific and technical achievements.

Therefore, the science and technology funds allocation methods that are currently in effect in a fundamental sense do not suit China's commodity economy. Restructuring of the science and technology system ought to begin first of all with a reform of the funds allocation system, cutting off the channel of "public grain," eliminating operating expenses for development and applications organizations, and changing the funds allocation methods by which research organizations report to higher authorities, listing projects, and seeking scientific and technical funding. It should also change the current planning and management system, should impel research organizations to cater to society, to cater to the realities of economic construction, to cater to the technology markets, to look everywhere for research topics, for funding, and for compensated transfer of the rights to technical achievements, all of which to strengthen gradually their own capacity for existence and development.

With this kind of outlook, development and applications research organizations will have eliminated operating expenses, and when management departments are arranging science and technology projects they should take this kind of research organization into consideration, for otherwise these units will find it difficult to survive. This is a consideration that should not be. There should be at least two ways of understanding the restructuring of the allocation system. As far as the research organizations are concerned, that will mean the elimination of research organization operating expenses and changing the way projects are reported and funds requested. The premise of working in this way is that we must acknowledge that technical achievements are commodities and that technology development and applications research units are the producers and operators of technical commodities. We must make it clear that their existence ought to be determined by the degree of commercialization they provide for society, and that they ought not to depend upon state allocation of operating expenses, nor should they rely on projects handed down by higher authorities for their continued existence. As far as funds allocation units or management departments are concerned, reforming the ways of allocating funds means that things should be carried out according to the rules of a commodity economy, using economic levers, and keeping to the principles of coordinated development of science and technology, the economy, and society in order to arrange how science and technology funding is to be put into operation. We should not link the circulation of science and technology funding to the existence of research units, for these are two different things and should not be discussed together. But in the present funds allocation system, these sorts of discussions are common. After certain operating expenses for research organizations had been eliminated, some organizations still pinned their hopes for subsistence on whether or not the higher authorities passed down scientific research projects for their particular unit or on how many they could hand down. What we have often criticized as "sympathetic projects" or "leading cadre projects" are reflections of this sort of problem. Therefore, we cannot consider that reform of the funds allocation system is just a matter for research organizations, because it is at the same time a reform of government organization and science and technology management systems.

How are we going to manage and use operating expenses and science and technology funding from the altered allocation channels? This is a problem posed to the government management departments by the restructuring of the allocation system. A scientific method would be to use this money together with money that can be gathered through other channels to establish a science and technology development fund, and to set up a fund committee composed of the departments of science and technology, economics, planning, and finance to manage the fund. The fund would primarily be used for key science and technology projects as presented in planning, for development projects, and for absorption and assimilation projects for imported technology. These projects will make use of the methods of public bidding opened to society at large, evaluation by specialists in the field, examination and approval by the fund committee, and preferential support. As responsibility projects handled through technical and economic contracts, whoever takes the responsibility will be supported. Whether it is a research organization or a higher level institution, or whether it is an enterprise. Aside from a small amount of risk capital for these projects, use of other project funds should be maintained on the compensation principle.

Benefits of the fund committee to manage and use science and technology funds as organized by the combined departments are: 1. it can consider and determine how to place science and technology funds from the macroscopic view of science and technology, economics, and society in coordinated development, so these things are not solely from the departments of science and technology. Therefore, in the decision making process this will change the situation where science and technology is divorced from economics, and allow it to become more scientific and reasonable. 2. It will break through the separation present in the current system due to each faction acting independently. An important factor in the separation between science and technology and economics in the past was that each department had its own planning. The department of foreign trade had a technology import plan, the economics department had a technology renewal plan, and the science and technology department had a plan for science and technology key developments, all of which were science and technology, but each was doing things its own way and there was little contact between them. This kind of system caused each department to proceed in a partial manner and lacked an overall view. To change this situation and make an impression from within this bound-up system would be very difficult. Therefore, setting up a fund committee where the combined departments participate in managing science and technology funds will be like waving a knife at the present system itself, and is a significant action and attempt. As for the management of technology importing and technology transformation funds, although each has its characteristics, as far as changing the decision making process and reforming the management system is concerned, the logic is the same. 3. Because the funds are open for bidding by the public, this enables research units, higher institutions, and enterprises to compete from the same starting line, and research units can then make efforts at competitiveness in technical research and development.

After allocation methods for science and technology funds have been changed, research organizations will on the one hand continue to strengthen the competitive capacity of technology research and development and strive to take on more of the bidding projects from higher authorities; on the other hand, research organizations will expand their vision, and seek projects in society, from enterprises, and in technology markets to find funds. Because of this, research organizations will restructure their internal management system, quicken the operating rhythm of each function, and provide for society more and more technical knowledge and products that are attractive and reasonably priced. At the same time, they will constantly increase the reserves of technical knowledge of the research organizations themselves, improve the levels of the work of scientists and technicians, maintain the "stamina" of scientific research and technical development, and in a planned way develop leading research. This is to say that after we have changed the allocation system, research units must have a commodity outlook and a view toward the marketplace. Research units will arouse an scientific and technical capacity that is greater than before to cater to enterprises and to the technology markets; a considerable number of scientists and technicians will leave the little heavens of the laboratory and extend their vision and energy toward economic construction.

Methods by which to restructure the allocation system will set up a new set of operating regulations for science and technology. This new system will be a working system having an organic structure and functions, as well as relations among them, and it will be complex. Therefore, restructuring the allocation system will not only change the allocation methods themselves, but the other "structures and their functions" that are related to it will carry out a corresponding reform.

First of all, we will vigorously open up the technology markets, which meets the preconditions of development of a socialist commodity market and of restructuring the allocation system. The technology marketplaces are channels of technical knowledge and commodities, and are the environment of a commodity economy. Opening up the technology marketplaces, we must first acknowledge that technology is a commodity and that it will create an environment that breaks up the "public grain" by which research units have obtained their income, existence, and development, and will create an environment by which research units can allow their technical achievements to reach their value in a commodity economy. We say "one side is building up the wall as the other is breaking free," by which we mean that one part wants to cut off the means of escape where the research units eat from the state bowl and where scientists and technicians eat from the unit's bowl; another wants to create an environment that allows research units to be able to exist and develop. Basing oneself upon this sort of environment will fulfill the chances for life; to depart from these surroundings will endanger life and limb. This environment is the technology marketplace. Compete, subsist, and develop in the technology marketplace. If something cannot fit within this environment, it will die out.

Then, we will extend the autonomy of the research units. Technology development and applications research units that have lost their "public grain" are producers and operators of technical knowledge and commodities, and therefore must eliminate all former bonds between the system and the research units. An example is where we will separate government from research, will permit research units to adjust their research directions based on their own strengths, will break through the piecemeal and fragmented restraints and the separation between departments, professions, and regions, cater to society, and form broad based relations with enterprises; we will permit research institutes to implement an institute director responsibility system, give decision making authority and command to the institute director regarding research, administration, and operations throughout the institute; we will allow research units to be not restricted by established authority, to select the best for employment and to advertise for needed personnel; we will permit scientists and technicians from research units to organize and form technology service organizations of all sorts that cater to society; we will permit research units to evaluate their internal technical positions; and we will allow the net income of research units to be retained by them, etc. In summary, we will treat research units from the view of a socialist commodity economy, and will use economic levers to manage research units. Leading organizations ought to be "hand maidens" and not become again a "sea of laws," nor treat research units as adjuncts to departments, nor use the method of administrative orders to manage the research units.

We will also formulate corresponding policies to support and impel research units in subsisting and developing in the actual practice of catering to economic construction. Research units are still infants in the marketplaces of a socialist commodity economy. Management departments will work out some corresponding policies to allow research units that have long relied for their subsistence on eating from the "public grain" to be able to have a suitable and ready program after "weaning from the grain." For example, in the steps to eliminate or reduce operating expenses we should treat research units according to their particular situations; within a certain period, to take out a portion of the eliminated or reduced operating expenses and return it to the research units through loans; in distributing income, as long as the research unit has begun to eliminate operating expenses and begun to turn toward economic construction, there should be an appropriate relaxation when it comes to distributing the technical income they have obtained, etc.

Changing the allocation system for science and technology funds will be a deep felt revolution for the science and technology system. It will not only require changing all aspects of the current situation, but will also require a thorough change in people's thinking and ideas. The present science and technology system has been formed gradually over decades, and to change an old system we must first request that the leaders, managers, and scientists and technicians from every level and department change their old thinking and ideas. We must request that people proceed from the actual conditions in our country, that they respect objective laws, and that they undertake repeated and arduous examination so that we may be able to establish an allocation system that impels science and technology to be closely linked with the economy, that we may be able to establish a set of operational regulations for science and technology that has Chinese characteristics, as well as to allow us to gradually get onto a good circulating track.

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PROBLEMS FOR YOUNG, MIDDLE-AGED S&T PERSONNEL DISCUSSED

Beijing ZHONGGUO KEJI LUNTAN [FORUM ON SCIENCE AND TECHNOLOGY IN CHINA] in Chinese No 1, Sep 85 pp 54-56

[Article by Jin Luzhong [6855 1462 1813], Zhang Wenrun [1728 2429 3387], Xu Jiayuan [1776 1367 6678], Hong Jialan [3163 1367 5695]: "A Survey of the Situation Regarding Young and Middle-aged Scientists and Technicians"]

[Text] Not long ago, we conducted a preliminary survey of the situation of young scientists and technicians in Beijing, Guangzhou, Shenzhen, and Shanghai.

I. The Importance and Seriousness of the Problem

Based on statistics from the end of 1983, among the nearly 7 million scientists and technicians in the natural sciences, those of middle age (36-55) constitute 56 percent and the young (35 and below) make up 41 percent, which is a total for the young and middle-aged of 97 percent. Among academic leaders and persons of technical responsibility, the young and middle-aged constitute the majority. Based on a survey of some scientific and teaching units in Guangdong Province, the young and middle-aged were 95 percent, and even within the Chinese Academy of Sciences, with its larger proportion of older scientists, among 6,000 project directors, young and middle-aged scientific and technical key members were more than 80 percent. In the period from 1978 to 1983, among the primary scientists and technicians for projects awarded prizes for invention, the young and middle-aged comprised 89.7 percent. It can be seen that not only are the young and middle-aged great in number, but that they are in positions of responsibility and have made great contributions. This generation of young and middle-aged scientists and technicians has already become the mainstay of China's scientific and technical contingent, and they are fulfilling the historical task of forming a link between the past and future, and of making China's science and technology prosper.

Currently, there are two prominent problems among the contingent of young and middle-aged scientists and technicians: the health situation is not good. A survey of several units has shown that the death rate among young and middle-aged scientists and technicians is about twice that of older people. The Academy of Sciences has provided the following statements: "The older generation holds longevity meetings, while the middle-aged hold memorial services," and "Middle-aged intellectuals are an attractive commodity at a reasonable price, but do not stand up to use." Because of this, some comrades have called out for "saving" the middle-aged scientists and technicians.

The other outstanding problem is that there is a "talent fault" lying beneath scientists and technicians. As apparent in the 26-35 age group, the amount of talent in both absolute and comparative numbers is small, and quality is lacking as well. Taking Shanghai as an example, in the 41-50 age group in this city, 51.5 of every thousand are college graduates, while among the 26-35 age group only 5.6 of every thousand have graduated from a college, which is a difference of more than 9 times. Looking from the point of view of absolute numbers, there are 65,000 of the former and only 14,700 of the latter, a difference of more than 4 times. The trough in population numbers is the crest in numbers of talent, which comes in the middle-aged group; and at the crest in population numbers is the trough in numbers of talent, which appears among the youth to constitute a "talent fault," or what some have called a talent crisis. Moreover, in another 10 years or so the problem will become more serious. The situation throughout the nation is like this. Therefore, there is also the problem of "saving" the young scientists and technicians.

II. Major Problems Among Youth Regarding Maturity and Fulfilling Their Roles

At present, outstanding scientific and technical talent is maturing slowly, and it is difficult to break out. According to a sampling and survey by the China Science Association, only one-fifth have carried out their functions well, three-fifths have partially done so, and one-fifth has not done so at all. The primary obstacles affecting complete fulfillment of their roles and maturity are:

1. Low scholastic positions. This is evidenced primarily in the fact that at every level of scholastic and technical leadership and review structure, the older generation of scientists are more numerous and the young and middle-aged rather less so. The problem of increasingly older scientific and technical leaders is far more serious than among party and governmental cadres, and the problem of the aging of knowledge is also rather severe. A considerable portion of people have been away from their specialties for many years and are actually laymen among professionals, which makes it difficult to do evaluations within the profession. Also, titles of professional and academic posts are not commensurate with the levels, abilities, and contributions. Abroad, instances where people in their 30's, and even those in their 20's, are professors or otherwise well known can be found everywhere. The older scientists in this country at present were also, for the most part, already professors or researchers in their 30's. But the situation at present is that there are 80,000 high-level specialists among natural scientists, among whom 51 percent are of the older generation. Only 1.65 percent of the total are 45 or under, and only 26 people are 35 and under, most of whom have come back to live from abroad. A great number of accomplished young and middle-aged key scientific personnel who have made contributions and are of a reasonable level, are still in middle grade posts, which has seriously suppressed their enthusiasm. Third, young and middle-aged scientists and technicians are without academic authority. For example, a number of middle-aged researchers

who are actually guiding the work of graduate students cannot be called graduate student advisors, and even those who abroad could guide the work of Ph.D. students cannot do so when they return home. And those who do guide the work of graduate students seldom personally do research work because of commitments throughout the year. The phenomenon whereby older scientists are given the credit while middle-level personnel are incidental is rather common in some units. In addition to this, "inbreeding" is rather serious, which has stifled the academic atmosphere. At some higher-level institutions, there are 4 and 5 generations of relatives, and younger and middle-aged scientists and technicians seldom have the atmosphere to make themselves known freely or to participate equally at academic conferences. This is especially true at the old-line colleges. Based on November 1984 statistics from Zhongshan University, among those teachers of the department of chemistry who graduated after liberation, 86.1 percent were graduates of that department in previous years, and in the analytical chemistry teaching and research section of that department the percentage of previous graduates is 96.6 percent. Because of this, they cannot develop the benefits of "cross fertilization," and new thinking is difficult to circulate, which even suppresses the maturation of outstanding talent.

2. Work responsibilities are heavy, and living conditions are deficient. Young and middle-aged scientists and technicians are currently carrying a great responsibility in our four modernizations, and will be decisive in it, but it is still such that at the age of 40 or 50, salary is 80 or 90 [yuan], there are one or two children, they are taking care of both their older generation and their younger, their responsibilities are great, living space is small, and it is hard to bring their energies and time to bear on their work. Difficulties in living are primarily manifested in low wages and cramped living conditions. According to the most recent statistics from the Chinese Academy of Sciences, among the 40-50 year old middle-aged scientists and technicians who currently have the greatest responsibilities, 80 percent have salaries from 78-89 yuan, which when you consider subsidies and total bonuses is lower than the national per capita monthly income of 47 yuan based on population averages. The wages of middle-aged intellectuals at research units and higher-level institutions is largely similar. The wages of younger scientists and technicians is even lower, and those college graduates who began school during the "cultural revolution" are currently earning about 56 yuan. Living space is not just a living condition for intellectuals, but is also a component of working conditions, as it is a place where mental efforts continue or deepen. Among the more than 30,000 scientists and technicians sampled and surveyed by the China Science Association, 64 percent demanded resolution of the housing problem. There are nearly 1,000 households where current per capita living area for scientists and technicians in the Beijing region of the China Academy of Sciences is not 3 square meters, even for three generations living together. Because work responsibilities are great and living conditions deficient, the physical conditions and states of health for middle-aged scientists and technicians are going down. According to a survey by the Chinese Medical Association of 11 units in Beijing, 81.6 percent of middle-aged intellectuals have some sort of chronic illness, which is higher than that of staff workers of the same age. The phenomenon of the early

deaths of the middle-aged is especially frightening, and has given rise to the scene where "the old send off their young," which has attracted the concern of many.

Since the 3d Plenary Session of the 11th CPC Central Committee, there has been a full scale attention paid to implementing policies toward intellectuals, which has won the deep gratitude of intellectuals. After several wage adjustments, the economic difficulties of middle-aged intellectuals have been alleviated. Some young and middle-aged have reacted with "the policy has been carried out for 70 and 80 year olds, while the burden has fallen on the shoulders of those with wages of 70 and 80 yuan a month," and for young and middle-aged intellectuals "there has been no end to good talk, but little good action."

3. Structures and systems are not conducive to competition, and lack internal motivation and pressure. Of the three major problems in this regard, one is that with management of scientists and technicians by party and government cadre, and unified distribution and assignment, scientists and technicians cannot move reasonably around. College graduates and graduate students who are assigned "according to need" never see each other, employing units cannot choose the best or be selective, "one is first married, then falls in love, and one's assignment determines the rest of one's life." Many units cannot meet their needs in talent and repressed talent cannot get free, which has given rise to a repression of talent in some units and a serious lack of personnel in others. Nor are high, middle, and low level personnel structures reasonable. A second problem is that the wage system currently in place cannot serve as an economic lever. There is no close connection between the quality of a scientist or technician's work and his material benefits, which gives rise to scientists and technicians "eating out of the same big pot." A third problem is lack of a set of science testing methods, a system of rewards and punishments, and a system and measures for encouraging talent to be top quality. Scientists and technicians lack internal motivation and pressure, and a "thousand li horse" would find it difficult to make much impression. At the opposite end is Shenzhen, where wages are not by age and there is strict testing, where people are obtained based on their abilities and contributions, where people are naturally put into competitive environments, where a group of young people and assistant engineers in their 20's and 30's have made quick progress, and where talent can show itself. A fourth problem is that the retirement system for scientists and technicians is imperfect, and in some places only middle levels and below are subject to retirement, which leads to the extraordinary phenomenon of "the daughter-in-law has retired, but her father-in-law has not."

4. Much is made of utility, little of training, knowledge has become obsolete, and retraining is lacking. In the world today, science and technology moves forward in leaps and bounds and the periods before obsolescence are getter shorter and shorter. The current problem is that the tendency to not pay attention to continuing education is rather serious. According to our preliminary survey of 32 units in Beijing, Guangzhou, and Shanghai, most units simply do not carry out the 3 to 6 month vocational refresher period every 3 years as provided for in the "Provisional Regulations for Cadre Management of Science and Technology" as issued by the Office of the

CPC Central Committee and the Office of the State Council. Training and education of youth in the fault has not received sufficient attention, and it has not been recognized that this is a strategic problem that concerns the four modernizations. Many have adopted an attitude that discriminates against and avoids those who graduated from college during the "cultural revolution," even to the extent of removing teachers or research positions, which has greatly undermined their self respect.

5. The influence of "leftist" ideology, old traditional concepts, and bad habits. For some departments and units there is really no solution for their dislike of talent. The outworn concept of revering the "head" and not the "family" is rather widespread. Sectarianism among scientists and technicians, disdain between literary people, and those who envy the worthy and are jealous of the capable have made it difficult for young and middle-aged scientists and technicians to fulfill their functions because of the "thick barrier" they create, which is not beneficial to reaching maturity. This is especially so for top notch talent that is thwarted by being talked about behind their backs and of whom perfection is demanded. It is even harder for these people to break through the barriers.

III. Suggestions for Accelerating the Maturation of the Young and Middle-aged and for Fulfilling Their Functions

1. Improve the academic and political positions of young and middle-aged scientists and technicians and encourage them to "establish their reputations as authorities." Among members of academic authoritative structures (degree holder's committees, professional evaluation committees, science fund evaluation committees, and awards committees), strive to have at least half be the qualified young and middle-aged. Members of these scholastic organizations are not in principle apart from the first line of research (teaching and production), and all who have been away for from 3 to 5 years and more should all go back into their academic organizations. With depth in their specialty, those young and middle-aged scientists and technicians who are suited to exploitative work in science and technology should be entrusted with the more important scientific and technical topics. Those who have quickly matured in actual practice and become leaders in the various scientific and technical fields should not be forced to assume administrative leadership. In evaluation of technical posts, scholastic and specialist levels and the extent of contributions should all be taken into account. For all primary scientists and technicians involved in science and technology achievements that receive national prizes for creative inventions, natural science awards, and scientific and technical advancement awards, for all those who in the past few years have been awarded the doctorate either here or abroad or who have made great accomplishments after so many years of actual scientific or technical work, for all those who have published academic papers of high quality in recent years, and for those who have been recognized by specialists in their fields, both here and abroad, as well as those scientists and technicians of a certain level who have actually guided the work of graduate students in recent years, be their qualifications and record of service greater or lesser, the problems of these people regarding promotion to higher posts should be considered foremost. Abolish the nominal system for guiding graduate students. Those accomplished and capable young and middle-aged people who have actually prepared and guided graduate students ought to

be qualified and authorized to guide graduate students in name. We should establish a young person's achievement award to encourage the young to make the most of their talent. Under working conditions, we should select the best and support a group of young and middle-aged scientific and technical core elements of attainments and who are outstanding, to allow them to mature as quickly as possible.

2. Implement a principle of allocation according to labor, the more done, the more one gets, and better work gets more. The recent restructuring of wages took this into consideration and recommended that from now on in further study of the principles for research wages, we should give full play to the important lever of wages. We will make the problem of housing conditions an important part of implementation of the policy toward intellectuals. We will make changes in the unreasonable phenomenon of "the more one studies the later housing is made available and the smaller the area." When housing is available, scientists and technicians should be considered first, especially those middle-aged scientists and technicians who most need housing, and we will strictly carry out the provision that one's years out of college will be one's standing regarding the availability of housing. For those who have made great contributions, better living conditions should be provided. All housing erected for use by intellectuals should be guaranteed for use by intellectuals.

3. Strengthen intellectual development, and pay attention to the promotion and cultivation of talent. On the basis of universally improving the quality of scientists and technicians, the focus will be to pay close attention to two types of people: one is that in selecting and cultivating top notch talent, make them into scientific and technical leaders; second, earnestly solve the "fault" problem in the scientific and technical contingent to ensure that science and technology has another generation.

We should strongly enhance the cultivation of graduate students because this will be the primary source of high-level talent, and entry level posts will eventually be filled by graduate students. We will break up departmental boundaries and permit employing units to come into higher institutions for recruitment 1 and 2 years before graduation, and at the same time will allow graduate students the right to choose their unit, allowing "provided as needed" to be faced earlier and to determine the direction of training. Encourage the young and middle-aged to go out of the country to earn their degrees and for advanced study, and for those leaving the country to participate in international conferences, or in cooperative research, or to teach, as long as the sponsor is providing funds, all sorts of excuses should not be found for keeping that person in this country. Technical examinations should focus on scientists and technicians.

We should respect the training of scientists and technicians already at work, and in addition to holding back on responsibilities, should also provide the opportunity for advanced training. We must formulate the "Rules for Continuing Engineering Education for Scientists and Technicians" as quickly as possible to allow systemizing continuing engineering education. Leaders at all levels should have a strategic view toward ensuring the time and conditions for refresher training. For that talent concealed in the "fault," we should adopt decisive "saving" measures. If we are to view them properly ideologically, we definitely cannot shun them but must warmly help them, and adopt various ways to vigorously cultivate them. Those who can benefit should likewise have the opportunity to go abroad for advanced study and to strive for academic posts.

4. Restructuring the management system for scientists and technicians will allow the outstanding young and middle-aged to break out from under. The core of this problem is in putting a hiring system into effect to accelerate the reasonable movement of talent and to permit academic leaders the "freedom to organize reviews," and create an environment of selection through competition. Economic policies relevant to the movement of talent should be complete and should allow the state, groups, and individuals to compete on the same basis. "Cross breeding produces superiority," so promote occupational exchanges between units, and especially between research units and higher institutions, to quicken the maturation of talent. At the same time, we want to break up the traditional habits of "inbreeding" and of "several generations employed together."

5. Continue to eradicate the influence of "leftist" ideology, further rectify understanding of intellectual labor and scientists and technicians, and overcome the worn out ideas that salary is according to age and that the "head" is to be valued over the "family." We should create a good atmosphere of warm-hearted support in society.

It is our belief that as long as we respect the maturing of young and middle-aged scientists and technicians and conscientiously solve certain practical problems, then a situation will persevere whereby talent appears each generation and where science and technology flourish and develop.

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SUGGESTIONS FOR OPENING S&T TECHNOLOGY MARKETS PRESENTED

Beijing ZHONGGUO KEJI LUNTAN [FORUM ON SCIENCE AND TECHNOLOGY IN CHINA] in Chinese No 1, Sep 85 pp 48-50

[Article by Guo Shuyan [6753 2885 6056]: "Vigorously Open Up Technology Markets, Push Forward Restructuring of the Technology System"]

[Text] The resolution by the CPC Central Committee regarding restructuring of the science and technology system is yet another grand strategic policy following upon the resolution to continue restructuring the economic system. The central link in this science and technology system reform is that it will change the situation that has been in effect for years now in which the rights to scientific and technical achievements are transferred without compensation, where topics selected for research are not directly related to markets, where there is a situation that creates barriers, where the military and civilian are separate, where the state controls everything about research organizations, and where scientific research is divorced from production. If we are going to allow science and technology be able to effectively serve economic construction, then we must allow the achievements of technology to become commercial and vigorously open up technology markets.

I. The Importance of Opening Up Technology Markets

To carry out the commercialization of technical achievements and open up technology markets, we must change to a great degree the operational regulations for the technology system. First, it will hasten developments in technology. Research organizations will determine research topics based on the market and the needs of society, even to extending applications. This changes the situation of the past that was purely tasking passed down from above, and will impel scientists and technicians to earnestly seek out, study, and solve technical problems in building production, will enhance motivation, and will also cause science and technology to be closely integrated with economic construction. Second, it will drive research units to consider technology development together with its contributions to social and economic construction, and together with their own economic results. This will consequently increase the impetus and activity catering to economic construction. Third, the objective reality of market competition will spur on research organizations and scientists and technicians that engage in development, and it will improve personal work efficiency and vocational standards. It will urge them to produce more results, produce better results, and to change their own results into production forces as quickly as possible. Fourth, a consequence of commercializing technical achievements is that whoever asks for something puts up the money; whoever buys something pays a fee. This will of course break up the boundaries that have existed for a long time between different levels, departments, regions, and the military and civilian sectors, hastening the socialization of science and technology. Fifth, opening technology markets will free the broad mass of scientists and technicians from the bonds of the old regulations, will stimulate their enthusiasm for invention and creation, and will provide an expanded arena of practice for all those who are competent and willing to research and for those who have come to their talent through self study. At the same time, it will urge talent and knowledge to move reasonably with the transfer of rights to technology. Sixth, through the exchange and application of technical products, their actual value will be fully evident. This will rid us of the old idea that "knowledge is not worth money," and will form an excellent social atmosphere that respects knowledge and respects talent.

II. New Trends in the Development of China's Technology Markets

Technology as a commodity already has a 2,000 year history abroad, and the modern day world technology trade has an even more unprecedented vitality. In China, the entrance of technology into the marketplace is an event of only the last few years. But there has been great life in it since its appearance there, and it has quickly entered a new stage in terms of content, form, scale, and pace as it develops in breath and depth. The trade fair for transferring military industrial technology to civilian use held in March this year in Hangzhou and the first national technology achievements trade fair are obvious proofs. We can see from these two trade fairs characteristics of the new trends in the development of our technology markets.

1. Some projects from planning have begun to enter the technology markets. Of capital construction, renewal, and key projects from provincial, municipal, prefectural, and county planning, 22 have entered the market as transactions for official contracts at amounts reaching above 10 million yuan, and 134 are for over 1 million, both of which together account for 88 percent of total transactions. The city of Danjiang in Hubei originally planned to invest 27 million yuan to erect a Chinese alpine rush pulp mill, but because they could not select the appropriate technology they put off starting for several years. But at the trade fair, they finally reached a technical agreement with the Hangzhou Office of Light Industry Machinery.

2. The number of items under engineering general contract (keys of exchange) has greatly increased. At the trade fair for technology achievements, many purchasers demanded to be provided with entire packages of technology, and 320 contracts were signed for 1.74 billion RMB, which was 60 percent of the business done. This did much to promote horizontal relations among the selling units, and provided a new path for improving the organization and implementation of planning projects. As for example where the Yaojie coal mine of Gansu signed a general responsibility contract with the Ministry of Light Industry affiliated Jingde Ceramic Research Institute, the Changsha Light Industry Design Academy, and the Light Industry Machinery Manufacturing

Company to use the coal mine's coke-oven gas and the abundant local pottery clay resources to produce colored facing brick and ceramic products. The responsibility contract included the whole process, from feasibility studies, ceramic techniques, engineering design, equipment manufacture, installation, debugging, to personnel training, for a total investment of 32 million yuan.

3. Import projects have entered trade fair bidding. As for example when the Liaohe Sweet Chrysanthemum Products Factory had originally planned to use 1.9 million U.S. dollars to import a sweet chrysanthemum glucoside production line from Japan. At the technology achievements fair, they discovered that the techniques and technology from Nankai University were both better than that of Japan, and they concluded this transaction for only 380,000 RMB. This sort of method that discovers domestic technical potential and saves on foreign currency is well worth our attention.

4. Use of the technology shareholding format. The transaction method by which scientific research units and enterprises jointly develop and jointly operate has been welcomed. At this technology achievements trade fair, about 18 percent of the transactions used this method. It can both alleviate funding pressures on the purchaser, giving the enterprise a long-term, stable technical basis, and can also allow research units to have a long-term, stable source of funding. Both parties to the shareholding share the risks and both parties share the benefits. The 8-year joint contract for the development of new plastic materials signed by the Beijing Chemical Engineering Research Institute with the Shangyu Plastics Factory of Zhejiang used just this format.

5. Applicable technical equipment has been welcomed. A large quantity of inconspicuous technology was welcomed by small and medium-sized enterprises and township and town enterprises, and according to statistics made up 60 percent of all projects at the trade talks and 38 percent of the total value. Small contracts under 100,000 yuan constituted 3.5 percent of the total values, while the number of such contracts were 83.3 percent of the total contracts. From the point of view of the number of projects transacted, the six liveliest professions were light industry, foodstuffs, and building materials, with petroleum engineering tied with machinery and electronics.

6. Banks and financial circles entered the technology markets. At this trade fair for technical achievements, some banks at the provincial and regional level, like Hunan, Hebei, Hubei, Fujian, Jilin, Shaanxi, and Shanxi, supported local transactions for projects with loans from several million yuan to several tens of millions, and they provided experience for science and technology circles, production circles, and financing circles. According to statistics from Hutan City, the development for which they used funds and credit to support advanced applicable technology has produced excellent results. For each yuan of circulating funds or credit, they gain 0.44 yuan per year, loans for equipment gain 0.77 yuan, while loans for technology development gain 3.43 yuan.

III. Principles, Policies, and Measures for Opening Up Technology Markets

The current principle is that we will further open up and invigorate in terms of policy, and the state, groups, and individuals may join together to develop the technology trade through hierarchical, multi-channel, and varied formats.

Not long ago, the State Council approved the establishment of a guiding small group to coordinate the national technology market, with the National Science and Technology Commission as head, and with the cooperation of the National Defense Science, Technology, and Industry Commission, and composed of 11 units from the Planning Commission, Academy of Sciences, Ministry of Education, Science and Technology Association, the Federation of Trade Unions, the Ministry of Finance, the Patent Office, the Office of Industrial and Commercial Administration and Management, the Bureau of Statistics, the Bank of Industry and Commerce, and the Office of the Science and Technology Leading Group. This group is charged with organizing forces, with macroscopic guidance of the technology markets, with formulating relevant laws and regulations, with linking data from various areas, and with expediting the development of the national technology markets. Recent tentative working plans by the coordinating group are: to arrange work on the technology markets over a few years time and to put it on track for adapting to the needs of the science and technology system and the economic system. Particular preparations will begin in the following aspects:

1. We will gradually set up and perfect the laws and regulations for the technology markets. Work out such things as management methods for the technology market, technology contract laws, ways to promote technical achievements, and a provisional statistics system for the technology trade. We will adjust some policies and regulations issued in the past that are not in tune with or are not coordinated with opening up technology markets; and will rectify as quickly as possible mishandling of technicians in the past regarding these areas.

2. We will formulate strong supporting policies and measures in the areas of pricing, tax revenue, credit, and allocation. According to the resolution by the Central Committee regarding restructuring the science and technology system, the state will not restrict pricing for the transfer of rights to technology, there will be market regulation, and it will be as determined by both parties to transactions. Income from the transfer of rights to technology will not be taxed for the near term. When selling new products, there will be a certain period of reduced or exempted taxes. Banks will use various forms of credit to support the technology trade. The state encourages scientific research units to undertake joint operations with industrial and mining enterprises on the basis of technology shareholding. To stimulate the enthusiasm of the three parties that are the buyer, seller, and middleman, their legal rights and interests will be guaranteed, and in profit retention and allocation we will handle carefully the relations between the state, groups, and individuals. In the situation where scientists and technicians are working at their own jobs, but where they use time apart from their work to deal with technical development and technical service to make additional contributions to the state and to society, this is a good thing that benefits the state and enrichens the people, and the compensation that they obtain

through their arduous efforts in only right. This will also impel some research units to quickly improve their work from the management point of view.

3. To spur on the most rapid prosperity for the technology markets, we will reform our own work in the three aspects of development, acceptance, and intermediaries. Technology development units will gradually change from the pure "planned research model" to the "research operations model," they will establish market concepts, will strengthen their competitive consciousness, and will set up and perfect operational structures for technical products. Outside of the unit, there will be compensated transfer of the rights to technology, and within there will be research topic responsibility, which will be freely constituted by personnel themselves. They will continue to improve the quality of personnel to react sensitively to complicated and changing social needs and to allow themselves to have the capacity to absorb foreign advanced technology, the capacity for self-development, and for self-renewal. Based on market surveys, market analyses, and forecasted demand, they will integrate their own characteristics, will formulate operational strategies for their own departments, and will determine and adjust development directions to better continuously select technical products that are competitive to supply to the technology markets. They will change the old situation whereby development work remained at the level of samples and exhibits, where technical achievements had to navigate through technical and economic passes, and they will solve the problem of packaging single technologies. They will not only solve the problems at the research, design, and trial production stages, but also will solve the problems of broadened applications, batch production, and exchange. They will become good at developing their own strong points, as well as at coordinating each faction and implementing all forms of alliances.

4. We will establish our own comprehensive trade system. We will maintain and support various organizations for technical exchange, trade, consulting, service, information, and certification. We must change the traditional idea that despises operational work, and will train and build up in actual practice a group of talented people with an aggressive spirit who both understand technology and know about operations. We will allow them to become the advertisers of the new production forces, and will reward those with outstanding accomplishments.

5. We will establish an unobstructed market information network, and properly manage the work of market statistics and forecasting. We will use modern methods to manage the gathering, dissemination, and inquiry into market information, will pay close attention to the tool that transmits data-- the newspaper, will run a newspaper the likes of TECHNOLOGY MARKETS, and will increase the amounts of our information. Each province and municipality will gradually establish and perfect their own technology information networks based on their own conditions.

6. Based on the two interrelated technology markets, international and domestic, we will become good at using two kinds of resources, and will learn how to use two sets of skills. We will absorb and import advanced foreign technology in order to advance the starting points of our progress forward.

At the same time, we will also develop, innovate on, and improve our level of technology through absorption and assimilation. At the same time as we import, we will also become good at using tariffs and administrative methods for a limited but necessary amount of protection for the domestic technology markets.

7. We will organize Chinese technology market research associations to further the theoretical study of technology markets. The questions of the value and pricing of technical commodities, and policies for distributing the income from transferring the rights to technology would be examples.

8. We will enhance the vitality with which enterprises absorb and develop technology. We will politically support and encourage enterprises in their use of new technology and in their development of new products; and we will provide support in the areas of funding, pricing, taxation, credit, inspection, and encouragement. We will gather our energy to develop sets of technology, to provide packages of equipment, and to change imported technology into our own technology. We will practice nationalization, and will work toward providing whole sets of technologies for the technology marketplace. Currently, those most urgently in need of technology are the town and township enterprises, deficit enterprises, and the small and medium-sized enterprises that are weak in technical capacity. Medium- to large-sized key enterprises would appear not to be in such urgent need of technology, but this is a temporary phenomenon. As restructuring of the economic and science and technology systems develops more deeply, the needs of medium- to large-sized enterprises will be constantly alive, and a technology market with even higher technical requirements and even greater capacities will develop before our eyes.

Carrying out the commercialization of technology and developing technology markets are completely new events. On the one hand we want to free up our thinking, be bold in opening up, and courageously put this into practice; on the other hand, we want to proceed from reality, investigate and study, give meticulous guidance, and constantly discover and resolve new problems that appear as we progress to allow us to develop healthily. It may be believed that unprecedentedly broad and prospering technology markets are certain to erupt throughout the country to impel the development of China's science and technology and its economic construction.

12586
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FUJIAN SCIENTIFIC INVESTMENT INCREASED 32.8 PERCENT

Fuzhou FUJIAN RIBAO in Chinese 9 Nov 85 p 1

[Article by Lai Jian [0171 7003], Si Huai [1835 2849] and Sun Yuan [1327 0626]: "Fujian Shifts the Focus of Scientific Advance toward Production"]

[Text] After adjustments, the scale of technical advance projects in Fujian's enterprises has returned to normal and the projects are proceeding satisfactorily. This was disclosed at the provincial report meeting on technical advance in the industry and trade sector which closed on 31 October. From last January through September, a total of 315 million yuan was invested in technical advance projects by industrial and transportation enterprises owned by the whole people, including technical modernization, import and technical development projects. That figure represents an increase of 32.8 percent over the corresponding period last year.

Since early this year, our province has been shifting the thrust of technical advance work toward putting projects into production and increasing economic results. Toward that end, we have been closely coordinating moves and cooperating with one another to solve practical problems. The provincial Economic Commission estimates that this year we will be able to complete 70 technical modernization projects using domestic equipment, 12 more than last year, each with an outlay of more than 1 million yuan. We will also be able to complete 120 technical modernization projects using imported technology, 16 more than in 1984. In addition we will come up with 200 high-grade products and adopt 130 international standards. Of the 165 new products listed as national and provincial new products, so far 109 have been put into production, and of the 64 new technology popularization projects, 54 have been completed.

12581
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ON SCIENTISTS AS ENTREPRENEURS

Tianjin TIANJIN RIBAO in Chinese 12 Nov 85 p 4

[Article by Xia Zuoyun [1115 0155 0061]: "More Scientists Should Combine Research with Business Management"]

[Text] The "Proposals of the CPC Central Committee on the Formulation of the Seventh 5-Year Plan on National Economic and Social Development" point out, "We must fully realize the decisive role scientific modernization plays in the four modernizations and further implement the principle that economic development must rely on scientific and technological progress, while scientific and technological work must orient itself toward the economy." To carry out the CPC Central Committee's "Proposals" conscientiously, scientific and technical workers must delve into production realities and conduct scientific research from the starting point of the needs of a developing economy. In addition, we need a host of scientists personally going in for entrepreneurship.

The scientist qua entrepreneur is a well-established phenomenon in foreign countries. The contributions of many famous scientists sprang from their combining science with entrepreneurship. Apart from being a great inventor with over 300 patents to his name, the world renowned Alfred Nobel was a superb industrialist, a commercial genius who knew how to run a business. Celebrated as an industrialist as well as scientist, he moved easily between the two worlds of science and business and pioneered several enterprises. Almost to a man, the founders of knowledge-intensive companies in the well-known Silicon Valley and Gene Valley are scientists: Hewlett-Packard, Apple Computers and Intel Corporation were all started by scientists doubling as entrepreneurs. Many scholars in the United States are also highly accomplished industrialists.

In China, too, numerous scientists have been involved in industrial development. Hou Deban [0186 1795 2831], the famous chemist, founded "Yongli Chemical Co" to market his technology and became a pioneer of China's modern industrial chemicals industry. Prof. Mao Yisheng [5403 0110 0581], the well-known contemporary specialist in bridge construction, is now concurrently manager of the China Bridge Co. Biologist Tan Jiazhen [6151 1367 2823], 76, recently became chairman of the boards of Universal Biological Co and Yangzi Optical Co. Today more than 100 people at the Shanghai Institute of Silicate

Research, Chinese Academy of Sciences, are hired by enterprises as consultants or technical advisers. Some hold concurrent posts as deputy director and manager. A group of modern experts who are proficient in production and management as well as scientific research is emerging. In the torrent of reform, they are demonstrating their diverse talents as scientists and enterprise managers and fast becoming key players on the stage in society.

Division of labor is a sign of social progress, but when division of labor becomes fragmentation, it does not help production development. In the past, some scientific and research workers seldom concerned themselves with the production side of an enterprise, severing arbitrarily scientific discovery and technical invention from production and application. As a result, the application of scientific research achievements was held up and their conversion into productive forces failed to materialize. Comrade Deng Xiaoping once said, "Now we must further resolve the problem of integrating science and technology with the economy." He also said, "Increase our productive forces." One of the best ways to integrate science and technology, on the one hand, and the economy, on the other, is to have scientists interested in entrepreneurs and doubling as entrepreneurs.

There are many unique advantages about scientists engaging in industrial development. First, as scientists, they are better equipped to strengthen enterprise management, adopt new technology to modernize old plants, old products and old technologies, speed up the transfer and dissemination of new technology, improve the standard of production technology, and accelerate the conversion of scientific achievements into productive forces, thereby stimulating economic growth. Second, when they double as industrialists, scientists get more opportunities to come into contact with the real world of production, understand market information more promptly and obtain feedback on scientific research work. Such feedback itself constitutes a test of their scientific achievements, which benefits the further development of science and technology. Accordingly, we should encourage some scientific and technical personnel to plunge into production practice with enthusiasm and get involved in industrial development. In the process we will transform scientific research from a closed world into a totally open system, thus furthering the principle that economic work must rely on science and technology and scientific work must orient itself to economic construction.

This article of course does not mean to suggest that every scientific and technical worker should go into industrial development. It only hopes that scientific and technical workers with an aptitude for business management will make full use of their intelligence and talents and play an active role in industrial development to promote the integration of science and the economy and make fresh contributions to the four modernizations.

12581
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SHANDONG REFORMS SCIENCE, TECHNOLOGY FUNDING SYSTEM

Jinan DAZHONG RIBAO in Chinese 6 Nov 85 p 4

[Text] Shandong Province has begun to reform the science and technology appropriations system by first tackling the three ways in which science and technology funds are managed.

In recent years, departments concerned at various levels in our province have all stepped up investments in science and technology. This year provincial appropriations went up 59 percent compared to 1980, while local appropriations rose almost 1.2-fold over 1982. To increase the social results of science and technology outlays, the province in the past few years has reformed in three ways the way we manage science and technology funds. First, signing project contracts to ensure that funds are paid back. Specifically, in the case of a priority project, the Science and Technology Commission, the unit which undertakes to do the project, and the department in charge are all parties to a contract. In the case of a regular project, the contract is signed by the department in charge and the research unit concerned. The department in charge supervises the use of project funds, ensures that funds are recouped and re-plans their use. In this way, the initiative of the department is further mobilized and management strengthened. Second, using credit as an economic mechanism. In the course of planning the second batch of planned projects this year, for instance, the provincial Science and Technology Commission set aside a portion of the funds as a science and technology development fund. Specialized banks loaned the funds to units in accordance with contract provisions and were also responsible for collecting them later. Consequently, of the 77 new projects, 37 were financed by loans and only 26.9 percent of the new projects' financial requirements consisted of straight grants. Third, in line with the spirit of simplifying administration and decentralizing power, the Science and Technology Commission offered some funds to help prefectures, counties and municipalities set up science and technology development funds, thereby almost doubling its appropriations this year compared to last year. To make sure the funds are well managed and put to good use, some prefectures and municipalities have come together to improve science and technology planning and adopted the "four synchronizations," namely, synchronizing the two kinds of planning, command and guidance; synchronizing municipal (prefectural) investments with county (municipal) investments; synchronizing funding management by the Science and Technology Commission with that by the banks; and synchronizing the contract system with the contracting system. The results of these measures have been very good.

As their effort to reform the funding system of scientific research institutes, the province, municipalities and prefectures last year selected 42 relatively well-qualified research units as the laboratory of their experiment in the gradual abolition of state operating grants. So far there are 36 scientific research units which require absolutely no operating funds from the state. These units undertake projects for outside parties in return for a fee. Internally they follow a project contracting system and all manner of responsibility systems. Last year their total income exceeded 35 million yuan, up 29 percent over the year before.

12581
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DEVELOPMENT OF GUANGZHOU TECHNOLOGY MARKET DESCRIBED

Guangzhou GUANGZHOU YANJIU [GUANGZHOU STUDIES] in Chinese No 5, 1985 pp 32-34

[Article by Zhang Jinzhi [1728 6930 2535]: "The Form, Characteristics, and Conditions for Development of the Guangzhou Technology Market"]

[Text] As a socialist commodity economy rapidly develops, a brand new market-- the technology market, is just now rapidly springing up and developing.

In early 1981, the Guangzhou Municipal Science and Technology Exchange Center and the Science and Technology Consulting Service Company were set up one after the other, and then in December of that year the first Guangzhou regional Science and Technology Achievements Trade Fair was held. Eighty-five units with 1,200 projects participated in the trade fair, including science and technology units stationed in Guangzhou and affiliated with the central authorities and the provinces, and from higher level institutions. During the period of the trade fair, more than 30,000 representatives of over 2,000 units came to the fair to look and talk things over, making transactions that reached 420,000 yuan in value. This was an important index for the Guangzhou science and technology market. Beginning at that time, technology trade activities, the primary components of which were developing the transfer of rights to technical achievements, technical service, science and technology consulting, and the exchange of talent, gradually began to build up throughout the city. Intermediaries for technical exchange, such as enterprises like the Science and Technology Development Company, the Science and Technology Exchange Center, the Soft Science Service Company, the Talent Development Company, science and technology street and science and technology shops, and science and technology consulting service companies, were established one after the other, and scientific and technical achievements and advanced technology began to enter the market as commodities. This fundamentally changed the situation of the past, where scientific and technical achievements and talent were owned by departments and locked into regions, and it changed the situation in which science and technology were divorced from production and where science and technology and the economy were two separate things, which consequently put new life into the development of science and technology and the economy in this city.

I. The Primary Forms of the Guangzhou Technology Markets and Their Characteristics

Currently, technology exchange in Guangzhou is through the following several types:

One is the soft technology trade market. This is primarily through various academic trade fairs and public lectures, as well as information materials and consulting services, to attain the goals of transmitting information, broadening knowledge, and mastering a technology. In particular there are:

1. Holding various forms of technology lecture courses and academic public lectures. This is an initial form of soft science exchange. The characteristic of this sort of exchange is that the scope is broad. In recent years, there were more than 700 foreign advanced technology lectures and academic public lectures sponsored by the Guangdong Provincial Science and Technology Commission and the Guangzhou Municipal Science and Technology Commission, to which more than 80,000 people from throughout the country have come to take part. The number of technical lectures and academic public lectures on domestic subjects had even more. Since 1980, the Guangzhou Office of Science and Technology Interchange has held 60 technology classes (including foreign languages and management) together with scientists and technicians from Hong Kong, Macao, and abroad, and with factories and stores, and has trained more than 11,600 students. The Guangzhou Academy of Chinese Medicine has been holding international acupuncture classes since 1980, for which more than 300 students have come to study from 45 countries and regions, among them Japan, the U.S., and Australia.

2. Developing various scientific and technical consulting services. Scientific and technical consulting services changed the situation where in the past groups would only take up academic exchanges, and where research units were divorced from production departments, which allowed science and technology to take some unfortunate steps as far as catering to production and to economic construction are concerned. According to incomplete statistics, there are currently 81 various types of scientific and technical consulting research organizations and consulting service companies, consulting service centers, and consulting service departments, 28 of which are full time consulting organizations and 53 are organizations that also offer consulting services. The subject matter for consulting services includes feasibility studies for technologies, equipment, and investment, and development, production and operations for new products and new technology. In 1984 more than 1,000 consulting projects were developed, which resulted in economic profits of more than 10 million yuan.

3. Sending scientists and technicians for observation and interchange. Through mutual observation and interchange there will be further opening of the channels of circulation for technical information, which has become a special component of the technology marketplace. For some years now, the provincial and municipal science and technology commissions have organized more than 40 groups with a total of over 2,000 people to go to Japan, the U.S., Australia, and Hong Kong and Macao for observation and study, at the same time greeting more than 400 groups visiting and interchanging from

foreign scientific and technical circles, for a total of more than 2,000 people. Even more have studied and participated in exchanges in various provinces and cities within this country.

4. Holding various information activities. All kinds of specialist books and newspapers and journals reflecting scientific and technical information have been published one after the other, and various information centers have also been successively established. Forty-two information networks (stations) have been set up for the science and technology information system that is centered on provincial and municipal science and technology information. This network has an intelligence contingent of more than 2,700 people, who provide a great deal of information materials for research and production departments. Through on-line retrieval by two large science and technology service organizations in Hong Kong and the rest of the world, computer terminals in Guangdong Province can quickly and completely provide science and technology information to scientific and technical and production units. This system has been in use for 8 months, during which time more than 4,000 people have come from throughout the country to use it, and it has provided more than 600 consulting services. The various specialist books published by Guangdong Provincial Science and Technology Publishing Company and other publishing departments, together with various publications established by all the technical schools and higher institutions, research departments, and academic groups have reached more than 300, with a total volume published in the millions each year. The Guangdong Provincial Science and Technology Library, the Zhongshan Library, and the Guangzhou Library, as well as the libraries (offices) of the various technical schools and higher institutions and the science and technology departments have more than 10,000 scientific and technical periodicals and millions of books on science and technology. The China Books Import Export Company, Guangzhou branch, has established long term professional relations with more than 8,000 publishing companies, bookstores, and academic research organizations in more than 100 countries throughout the world, to provide a scientific and technical book service both within and out of the province.

Second, are the hard technology markets. They carry on technical trade chiefly in the form of exhibitions of scientific and technical achievements, trade fairs, and cooperative trouble-shooting conferences. More specifically, they are:

1. Holding various exhibitions, interchanges, and trade fairs for scientific and technical achievements. Using these formats, higher institutions and science and technology design units can directly discuss cooperative projects with production departments, to more quickly reach agreements and sign scientific and technical cooperative contracts. As for example the first Exhibition and Exchange of Scientific and Technical Achievements held in the Guangzhou region in 1982, in which 85 higher institutions and research units participated, at which there were 1,292 technology achievements, and where there were more than 70 scientific and technical achievements and products registered as available for sale. During the period of the meeting, contracts were signed for the transfer of the rights to 15 of these.

2. Developing various domestic joint activities involving imports. Functioning through economic levers, these have crossed regional and department boundaries, allowing advanced science and technology to be transferred from science and technology units to production departments, from military to civilian use, from the coasts to inland, and from outside the country to within it. Based on incomplete statistics, from 1979 through 1984 there were 283 Chinese-foreign jointly funded cooperative projects and compensation trade contracts signed or contracted for throughout the city; there were more than 14,000 contracts for processing of imported materials and for assembly of imported parts; more than 150 production lines were imported, as well as tens of thousands of sets of advanced equipment; more than 1,300 contracts and agreements have been signed for economic and technical cooperation with enterprises and units from 21 provinces, cities, and autonomous regions, for a total investment of 390 million yuan; and 31 technologies have been brought in from other provinces and cities, 21 have been taken out, and 21 raw material bases were set up.

3. Organizing various scientific and technical project trouble-shooting conferences. In 1984, Guangzhou arranged 141 scientific and technical projects to tackle key problems, and more than 300 trouble-shooting conferences and demonstrations of all sizes have been held.

4. Setting up various scientific and technical trade organizations, like science and technology stores. At present, there are 343 technical service and trading organizations throughout the city, and 39 science and technology stores. These stores exhibit, market, and transfer the rights to new scientific and technical achievements, develop technical consulting services, undertake technical training and technical problem solving discussions, and also handle advanced foreign and domestic teaching instruments, medical instruments, computers, household appliances, and photographic materials. One street in the science and technology market attracted a large number of customers from both within and outside the province and business prospered, which promoted scientific and technical exchange and trade. After being open for less than 6 months business had already reached 9 million yuan, until at present daily business is more than 50,000 yuan.

Third, is an organic market. By this is meant chiefly expositions and trade fairs for various new products, new technology, new techniques, and new equipment. As for example the China Export Commodities Trade Fair held in Guangzhou, as well as the "Beautify Guangzhou" Fair and the Light Industry Products Exhibition Marketing Fair. New products emerging in a constant stream compete in the marketplace, which is actually competition in technology, and the products exhibited also reflect to varying degrees the technical level and real economic strength of China and Guangzhou.

II. Far Reaching Changes Brought by the Prosperity of Technology Markets

The appearance of science and technology markets struck out at various straightjackets that bound scientific and technical and economic development, they quickened the pace of restructuring the science and technology system, promoted exploitation and development of new technical fields, and accelerated economic prosperity.

1. They have raised the value of knowledge and technology, gradually forming an attitude in society that respects knowledge and talent. In the far-reaching technology trade, the value of technology has been acknowledged; intellectuals and mental labor has been honored, and this has caused the study of technology, pursuit of an education, and seeking after knowledge to be common practice throughout society. To meet the requirements of staff in seeking an education and studying technology, all professions and enterprises throughout the city have started up 548 on-the-job and technology schools, for which by the end of 1984 there were 380,000 staff students. Schools run by society have developed abruptly, and there are more than 160 supplementary and night schools with more than 50,000 students; 330,000 people have an supplemental education, have passed tests, and have attained junior middle school level educations, which is 61 percent of those throughout the city who take junior middle school supplementary classes; 250,000 people have tested to a level of high school, which is 69 percent of the staff taking supplementary classes.

2. Scientific research has been even more closely linked to production, and the rate at which the achievements of scientific research have extended to applications has improved everywhere. In 1984, 30 specialist research institutes affiliated with the city completed a total of 125 research projects, 87 of which were applied that same year, for an extended applications rate of 69.6 percent, which was 20 percent higher than in 1978.

3. Work efficiency in scientific research units has improved, economic income has increased, and research conditions have improved accordingly. In the past, a scientist or technician at the provincial electronics research institute took an average of 18 years to produce an achievement, while among the 15 projects contracted for in 1984, the project that took longest to complete needed only five people and 19 months. According to statistics, in 1984, 39 research institutes affiliated with the city had an income of 6.6 million yuan, which was nearly 3 times that of 1981, and was a 65.8 percent increase over 1983. In 1984, of 37 applications development institutes affiliated with the city, 21 have newly built laboratories to begin solving the problems of experimental sites.

4. Having cleared the channels of technology transfer, this has accelerated broad technical cooperation and economic integration. A large number of new achievements and new technologies have been exchanged in the markets, and have obtained clear economic and social results. As technical commodities circulate, joint cooperative relations of all sorts will be gradually established. According to 1984 year-end figures, throughout the city relations have been established with more than 200 technical and vocational schools, scientific research organizations, academic groups, factories and stores, and companies in more than 20 countries and regions, and internal joint cooperative relations have been established inside China with technical and vocational schools, research departments, and enterprises in 21 provinces, cities, and autonomous regions. Independent specialist institutes just within the city area have developed about 100 projects with 127 units from 18 provinces and cities for technical service, achievement rights transfer, and for selling new scientific and technical products.

5. They have promoted the reasonable movement of intellectual and scientific and technical talent. Since its inception in 1983, the Provincial Talent Exchange Center has worked as a "go-between" and a "bridge" in talent exchange, and by the end of 1984 more than 4,500 specialists of all sorts had gone to register, and more than 400 employing units had preliminarily selected some 1,300 people, among which more than 400 had already filed the paper work for transfer. At the 5-day Guangzhou Talent Exchange Fair held in August 1984, more than 8,700 people were requesting to move, 3,100 among which have already been preliminarily selected by employing units, and more than 200 had arranged for transfers not long after the fair.

III. How Can We Make the Guangzhou Technology Markets More Prosperous?

The work of opening up technology in this city has just begun, and there are still some problems needing urgent attention that will require earnest study for resolution.

1. Strengthen the macroscopic management and guidance of the technology markets. We must strengthen macroscopic management and guidance regarding development directions and scale of the technology markets. We will keep to the principles of opening up to reforms, equally and without discrimination and uniformly encourage and support technology markets, whether they are year-round or temporary, specialist or general, regional or departmental, or run by units or the masses, groups, or individuals. We will gradually establish and perfect a system of laws and regulations for technology markets, and will as quickly as possible formulate things such as laws for technology market management, management laws for scientific and technical cooperative contracts, scientific and technical consulting laws, and laws for the movement of scientists and technicians.

2. Enhance the research into technology market policies. Technology markets are a new thing in China, and in the process of their emergence and development many problems of a policy nature will require study. As for example the problems of technology product value, pricing problems, and allocation of income from the transfer of the rights to technology, all of which will require study and investigation both theoretical and practical. Banking, finance, and taxation departments will all draw up strong supporting policies and measures that will be convenient and preferential for technology markets, especially in the areas of pricing, taxation, credit, and distribution. As for those policies and provisions that had been promulgated before and are not in keeping or coordination with opening up technology markets, they should be quickly adjusted. We will pay close attention to motivating the enthusiasm of the buyers, purchasers, and middlemen, and to guaranteeing their legal rights. As for profit retention and distribution, we will make clear the relations among the state, groups, and individuals.

3. To promote the further prosperity of the technical markets, we must pay close attention to the restructuring of the three links for scientific and technical achievements that are their development, acceptance, and the intermediaries, based upon the needs of opening up the technology markets and hastening the commercialization of scientific and technical achievements.

One, institutions of higher learning or a research units will gradually change from a pure "planned scientific research model" to a "research operation model." They will securely establish a market concept, an operational concept, and a sense of competition, they will set up and perfect their own operational structures and technology service systems, and they will industriously generate for the technology market technical commodities that are high in quality and for which there is a market. Two, production enterprises will improve enthusiasm for using new technology and will strengthen their economic capacity for purchasing technical achievements. Speaking fundamentally, the prosperity of technology markets will depend upon the demands on technology by production, while the needs of enterprises for technology is also closely related to state policies toward using new technologies and the economic vitality of the enterprises. Therefore, we will politically support and encourage enterprises to use new technology and develop new products, and adopt effective supporting policies through financial channels, pricing, taxation, credit, inspection, and rewards. Enterprises themselves should greatly strengthen their own capacities for technical absorption and development, and relying upon a constant renewal of products from science and technology, should resolve a series of technique and equipment problems regarding quality in industrialized production, consumption of raw materials, and productivity. We will open and guarantee financial channels for technology absorption and development, and will draw up indices based on technology for implementing enterprise economic appreciation. Three, initiate and develop more technology exchange, trade, consulting, service, information, and certification structures of various types, and organize and train technical operations contingents throughout the city to gradually establish and perfect a complete trade system for technology markets. We recommend that the city appoint or create a special organization to be responsible for coordination and unified management of these things and to meet the urgent needs for the rapid development of current technology markets.

4. We will resolutely implement an open-door policy, will connect up domestic technology markets with foreign technology markets, and will consider the absorption, assimilation, innovation on, and transfer of imported advanced technology to be important matters in opening up technology markets that have Guangzhou characteristics. By connecting up imported technology with joint domestic operations, and by joining technical talent and intelligent imports, we can give full play to the function of Guangzhou as a "hinge between two parts of a door."

12586
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NATIONAL DEVELOPMENTS

TECHNICAL MARKET THRIVING IN HEBEI

Shijiazhuang HEBEI RIBAO in Chinese 12 Dec 35 p 4

[Article by Shi Pengjun [4258 2590 0689]: "The Technical Market is Thriving in Hebei"]

[Text] The development of the technical market, the commercialization of technology and the acceleration of the entry of technical achievements into the production arena--all this is required by the development of a socialist commodity economy. For over a year now, the Hebei technical market has been flourishing and achieved remarkable results. More than one half of the province's prefectures, counties and municipalities have established permanent technical markets. All localities are launching technical trade activities, besides importing and popularizing a multitude of technical achievements and establishing technical and economic cooperative relations with Beijing, Shanghai and Tianjin in order to promote economic development. At our province's first and second technical achievement trade fairs alone, attended by 20,000 men times, 1,945 technical achievements were traded, worth a total of 36.31 million yuan. Hebei led the nation's provinces, municipalities and autonomous regions in volume of business transacted at the national technical achievement trade fair held in Beijing in May this year.

So far the province has imported and popularized over 4,100 technical achievements through the technical markets, established almost 1,000 scientific research cum production joint organizations with 200 institutions of higher education and research and design units outside the province, and attracted over 4,000 people to Hebei to join us in technical development. We have invented and put into production more than 1,000 new products, many of which have become competitive flagship products. From the simple transfer of technical achievements, the technical market has diversified into an array of services, including the circulation of qualified personnel, bidding for planned scientific research projects, contracting, joint ventures in which one can use technology as capital, joint development between a research unit and a production unit, and the establishment of research-production joint organizations. To increase the purchasing power in the technical market, the financial sector is also getting involved. The provincial science and technology service center, for instance, borrowed 16.25 million yuan this year to support 102 projects extensively.

Over 80 units from Beijing, Shanghai and other places in and outside Hebei will take part in the coming third provincial technical achievement trade fair and talks, bringing with them 1,500 pieces of technical achievements for transfer with compensation. In addition, 1,500 pieces of technical information of various kinds will be announced. The occasion is expected to give a further boost to our technical market.

12581
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BRIEFS

GUANGDONG TECHNOLOGY IMPORTS--Over the past few years, industrial and communications enterprises in Guangdong Province progressed in importing advanced foreign technology and equipment. From 1982 to the beginning of this year, the province imported 700 items of production and assembly lines and 500,000 sets of equipment. With this technology and equipment, the province has scored marked economic results. Over the past few years, after importing technology, our province has produced approximately 10,000 new varieties. The province's gross industrial output value over the past few years has increased by a yearly average of 9 percent. [Summary] [Guangzhou Guangdong Provincial Service in Mandarin 0400 GMT 28 Jan 86 HK] /12232

TECHNOLOGY IMPORTS--Shenyang, 25 January (XINHUA)--The province of Liaoning, center of China's heavy industry, signed 1,190 contracts for imports of foreign technology worth 860 million U.S. dollars last year, a local official said today. Zheng Silin, who is in charge of this province's foreign economic relations and trade, said last year's imports brought the total number of contracts since 1978 to 2,689 at a total cost of 1.59 billion dollars. Most of the imported technology has been used to renovate more than 1,000 of the province's 16,000 industrial enterprises involving energy, transportation, metallurgy, machinery, electronics, postal and telecommunications, chemicals, building materials, textiles and light industry. In addition, Zheng said, the province's power transmission industry has been modernized to the point where it can export complete equipment systems and undertake construction projects abroad. Imports have also played an important part over the past seven years in developing Liaoning's 12,700 new products, nearly 9,000 of them already in production. The import trade--requiring use of foreign investment--was with more than 20 countries and regions, including Hong Kong, Britain, the Federal Republic of Germany, Italy, Japan, Sweden, and the United States. [Text] [Beijing XINHUA in English 0835 GMT 35 Jan 86 OW] /12913

CSO: 4020/198

PHYSICAL SCIENCES

IMAGING EQUATION, OPTIMUM ESTIMATION, ALGORITHM OF ULTRASONIC HOLOGRAPHY

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 3, May 85 pp 71-76

[Article by Li Zaiming [2621 0961 6900] of Chengdu Institute of Radio Engineering and Wu Junti [0702 6511 6452] of P. O. Box 359, Dayi, Sichuan*]

[Text] Abstract: The imaging equation, optimum estimation model and computer algorithm of ultrasonic Fourier holography are discussed. The effect of background interference and its elimination are analyzed. Good results were obtained using this model and algorithm.

In order to facilitate computer processing of multi-dimensional information, we employed an information estimation and functional analysis method to discuss ultrasonic Fourier holography. This method has advantages such as clear concept and well-defined capabilities. Furthermore, it can facilitate software design. The resulting imaging effect is better than that reported in the literature.[1]

I. Experimental System and Mathematical Imaging Model

The overall three-unit experimental system usually consists of an ultrasonic imaging unit, a computer processing unit and a display unit as shown in Figure 1. In the ultrasonic imaging unit, the emitter produces a series of carrier frequency pulses (e.g. 5 MHz or 1 MHz) at a fixed power toward the emitter transducer. In a certain sense, an emitter transducer with lenses can function as a point source to irradiate a target at a certain distance. An ultrasonic field, i.e. the so-called body function distribution, is established on the target plane as a result of this irradiation. The ultrasonic field distribution on this plane is subsequently recorded by a scanning receiver on a parallel plane, which is called the holographic function distribution. The required complex holographic data can be obtained and recorded on tape by using a dual channel orthogonal demodulator and a microprocessor. There is a well-defined mathematical correlation between the body function and the holographic function, i.e. the imaging equation.

We established the optimum estimation model and algorithm through analysis to process measured holographic data by a computer to obtain a relatively accurate image of the target.

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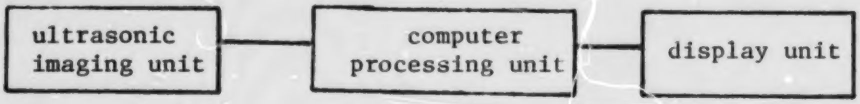
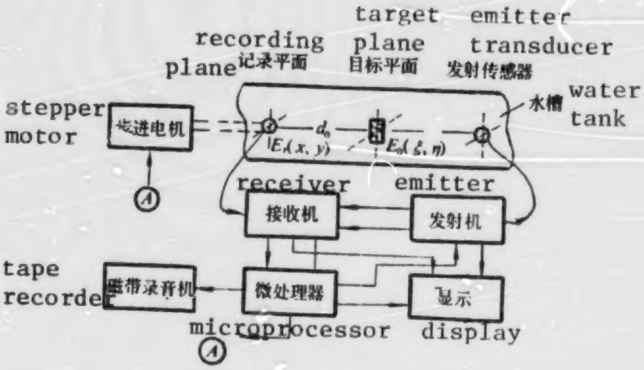
*Received in August 1983, finalized in February 1984.

Figure 1. The Experimental Ultrasonic Holographic System

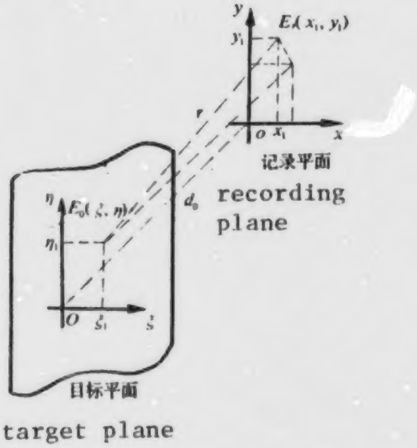

ultrasonic imaging unit
computer processing unit
display unit

(a) System Scheme


recording plane 记录平面
target plane 目标平面
emitter transducer 发射传感器
water tank 水槽
stepper motor 步进电机
d_0
$E_r(x, y)$
$E_0(\xi, \eta)$
receiver 接收机
emitter 发射机
tape recorder 磁带录音机
microprocessor 微处理器
display 显示
A
A

(b) Ultrasonic Imaging Unit

Figure 2. Target Plane and Recording Plane Coordinates


y
$E_r(x_1, y_1)$
y_1
r
o
x_1
x
记录平面
recording plane
d_0
η
$E_0(\xi, \eta)$
η_1
O
ξ_1
ξ
目标平面
target plane

1. Mathematical Description of the Ultrasound Field

The target plane and recording plane coordinates are shown in Figure 2. Let us assume that $E_0(\xi,\eta)$ and $E_r(x,y)$ are ultrasonic station functions in the parallel target and recording coordinates. The ultrasound signal picked up by the receiver at (x,y) is the superposition of all irradiating elements on the target plane. According to the Huygens-Fresnel principle,[2] we get

$$E_r(x,y)=\iint\limits_{(\xi,\eta)}\frac{B}{r}E_0(\xi,\eta)\exp\left[-j2\pi\frac{r}{\lambda}\right]d\xi d\eta \quad (1)$$

where λ is the wavelength of the ultrasound in the medium and B is a proportional constant (independent of r, ξ and η).

In practice, the size of the target and the recording plane are limiting. Moreover, its degree of linearity is far less than that of their separation distance do. Let us assume that they are limited by (2ax2b) and (2cx2d) windows, respectively. Based on the Fresnel approximation, the distance r in the exponent term in the above equation can be simplified to:

$$r \approx d_0 + \frac{x^2+y^2+\xi^2+\eta^2}{2d_0} - \frac{x\xi+y\eta}{d_0} \tag{2}$$

The absolute error is less than

$$\max\left(\frac{|x-\xi|^4}{8d_0^4}, \frac{|y-\eta|^4}{8d_0^4}\right)$$

The relative error of the absolute value satisfies the following

$$\varepsilon_r < \max\left(\frac{(c+a)^2}{4d_0^2}, \frac{(d+b)^2}{4d_0^2}\right)$$

Here, the mathematical symbol max(A,B) represents the larger of constants A and B. From equations (1) and (2) we get

$$E_r(x,y) = B_1 \cdot C_d(x, y, , d_0) \cdot \iint_{(\xi,\eta)} E_0(\xi,\eta) C_d(\xi,\eta,d_0) \exp\left[-j2\pi \frac{x\xi+y\eta}{\lambda d_0}\right] d\xi d\eta \tag{3}$$

where

$$C_d(x,y,d_0) = \exp\left[-j\frac{\pi}{\lambda d_0}(x^2+y^2)\right]$$

B_1 is a constant. By introducing a window function

$$W(\xi,\eta,a,b) = \mathrm{rect}(\xi/2a, \eta/2b)$$

where

$$\mathrm{rect}(\xi,\eta) = \begin{cases} 1, & -1/2 \leqslant \xi, \eta \leqslant 1/2 \\ 0, & \text{other} \end{cases}$$

then equation (3) can be written as:

$$\begin{aligned} E_r(x,y) &= B_1 W(x,y,c,d) C_d(x,y,d_0) \\ &\cdot \iint_{-\infty}^{\infty} E_0(\xi,\eta) W(\xi,\eta,a,b) C_d(\xi,\eta,d_0) \\ &\cdot \exp\left[-j2\pi\left(\frac{x}{\lambda d_0}\xi + \frac{y}{\lambda d_0}\eta\right)\right] d\xi d\eta \end{aligned} \tag{4}$$

By using the two-dimensional Fourier transformation operator F[·], the above formula can be expressed as:

$$E_r(x,y)=B_1W(x,y,c,d)C_d(x,y,d_0)\cdot F[E_0(\xi,\eta)W(\xi,\eta,a,b)C_d(\xi,\eta,d_0)] \qquad (5)$$

At this point, we can conclude as follows: the measured data $E_r(x,y)$ and the body distribution of the target are roughly a pair of Fourier transforms if the relative error, E_r, is tolerable. The measured data $E_r(x,y)$ is often known as the complex hologram. The relation between the complex holographic function and its corresponding body function is shown in Figure 3. From the figure one can see that a complex holographic function may also be considered as a distorted body function. Hence, equations (4) and (5) not only can be called imaging equations but also distortion equations. Figure 3 is also an imaging or distortion diagram.

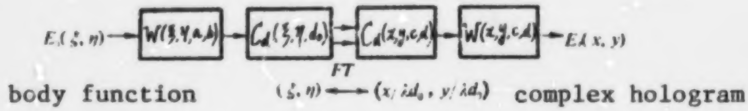


Figure 3. Relation between Body Function and Complex Holographic Function

2. Measured Complex Holographic Data

To obtain the complex holographic data, two channels (as shown in Figure 1(b) could be used. Equation (5) obtained by using a microprocessor may be in one of the two following cases:

$$E_r(x,y)=\mathrm{Re}[E_r(x,y)]\pm j\,\mathrm{Im}[E_r(x,y)] \qquad (6)$$

In reality, the theoretical analysis of both cases is identical. For simplicity, only the plus sign is used in the following analysis.

3. Effect of Background Interference and Its Elimination

The ultrasound field distribution on the target plane can be considered to include background interference and target field. Therefore, we can establish an additive model

$$E(\xi,\eta)=E_{01}(\xi,\eta)+E_{b1}(\xi,\eta) \qquad (7)$$

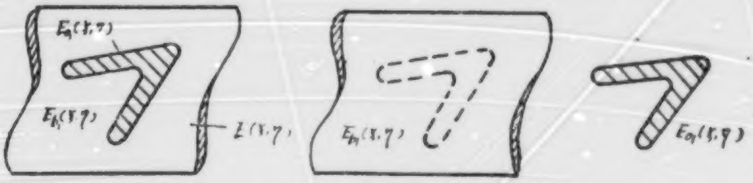
Here, $E_{o1}(\xi,\eta)$ is the field distribution of the target and $E_{b1}(\xi,\eta)$ is the field distribution of the background disturbance. They can be expressed as:

$$E_{01}(\xi,\eta)=\begin{cases}E_0(\xi,\eta), & \text{in target area}\\ 0, & \text{other}\end{cases}$$

and

$$E_{b1}(\xi,\eta)=\begin{cases}0, & \text{in target area}\\ E_0(\xi,\eta), & \text{other}\end{cases}$$

In ultrasonic holographic imaging, it is satisfactory to use the above additive model to eliminate background interference (as shown in Figure 4).



(a) field distribution on target plane (b) additive model

estimated target with background interference

estimated background interference

estimated target without background interference

(c) an example to use additive model to eliminate background interference

Figure 4. Additive Model of Background Interference and Its Elimination

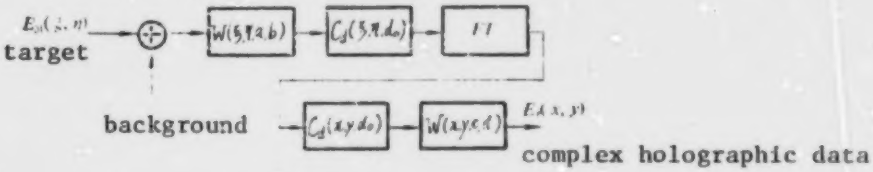


Figure 5. Imaging Function Capable of Eliminating Background Interference

In summary, based on the additive model, the complex holographic imaging expression (5) can be written as:

$$E_r(x,y)=B_1\cdot W(x,y,c,d)C_d(x,y,d_0)\cdot F[W(\xi,\eta,a,b)C_d(\xi,\eta,d_0)(E_{01}(\xi,\eta)+E_{b1}(\xi,\eta))] \tag{8}$$

This equation can be verified by Figure 6.

II. The Optimum Image Estimation

1. Mathematical Model for Estimation

When the complex holographic data is given, to estimate or restore a target image is to solve equation (8). If parameters such as the window of the ultrasound system are properly chosen (to be discussed elsewhere), then the window effect can be neglected. Thus, the optimal estimated image can be expressed as:

$$\hat{E}_{01}(\xi,\eta)=C_d(\xi,\eta,-d_0)F^{-1}[C_d(x,y,-d_0) \cdot E_r(x,y)]-E_{b1}(\xi,\eta) \tag{9}$$

It should be noted that the spatial frequency variable is $(x/\lambda d_0, y/\lambda d_0)$. in performing an inverse Fourier transform. The background interference can be expressed as:

$$\hat{E}_{b1}(\xi,\eta)=C_d(\xi,\eta,-d_0)F^{-1}[C_d(x,y,-d_0)\cdot E_{rb}(x,y)] \tag{10}$$

In practice it is possible to measure $E_{rb}(\xi,\eta)$; without involving the target when the remaining conditions stay unchanged. Then, $\hat{E}_{b1}(\xi,\eta)$. can be calculated on a computer based on equation (10). The multiplication of the factor function $C_d(\xi,\eta,-d_0)$ in the target estimation equation(9) can be re-written as:

$$\hat{E}_{01}(\xi,\eta)=\mathrm{Mag}[F^{-1}(C_d(x,y,-d_0)(E_r(x,y)-E_{rb}(x,y))] \tag{11}$$

where the mathematical symbol Mag[A] - $|A|$.

2. Computerized Processing

The concept of computerized processing of equation (11) is to first sample the original field and then periodically extend the sampled field to obtain a sampled periodic field distribution which is used in the computation. One cycle of this field distribution coincides with the sampling approximation of the original field. This method calculates the effect of FT by using DFT. This important concept is shown in Figure 6. Let the target field and complex hologram to be processed by the computer be $E_{01c}(\xi,\eta)$ and $E_{rc}(x,y)$, respectively, then we have the following relation:

$$E_{01c}(\xi,\eta)=E_{01}(\xi+la_1,\eta+mb_1)$$

and

$$E_{rc}(x,y)=E_r(x+lc,y+md)$$

where l and m are 0,1,2,....... The imaging elements of the target field (i.e. the target picture) a_p and b_p are:

$$a_p=\lambda d_0/c, \qquad b_p=\lambda d_0/d$$

The image size in one basic cycle is:

$$a_1=\lambda d_0/c_p, \qquad b_1=\lambda d_0/d_p$$

It is obvious that the following condition must be satisfied to avoid distortion caused by mingling of neighboring high frequency components.

$$a_1 \geqslant a, \qquad b_1 \geqslant b$$

In order to obtain a clear picture and to prevent serious high frequency mixing, it is necessary to have a large plane to measure the complex hologram. In approximation, most of the target image spatial frequency components should be concentrated in the spatial frequency range $(c/\lambda d_0, d/\lambda d_0)$内。

image

CxD frequency spectrum

(a) Image and Is Frequency Spectrum

(b) Computer-generated Image and Frequency Spectrum

Figure 6. Using DFT to Calculate the Effect on FT

Estimation is made according to the following method:

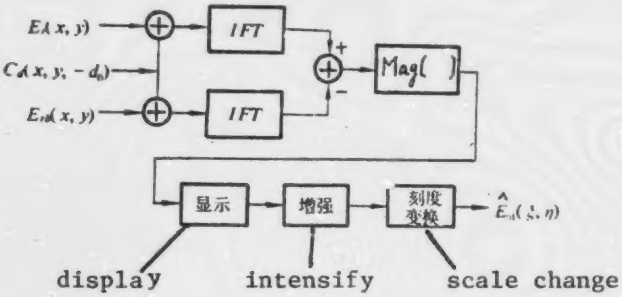
(1) Known Data. $E_r(x,y)$, $E_{rb}(x,y)$ and the following system parameters such as focusing distance d_o, ultrasound wavelength in the medium λ, sampling space C_p and d_p (usually $C_p=d_p$ and target display dimensions d_{s1} and d_{s2} (usually $d_{s1}=d_{s2}=d_s$) are given.

(2) Algorithm and Procedures. Focus, call function subroutine, $C_d(x,y,-d_o)$, and then do the multiplication $E_r(x,y)\cdot C_d(x,y,-d_o)$ and $E_{rb}(x,y)\cdot C_d(x,y,-d_o)$. Call the DIFT subroutine to calculate $F^{-1}[E_r(x,y)\cdot C_d(x,y,-d_o]$ and $F^{-1}[E_{rb}(x,y)\cdot C_d(x,y,-d_o]$. Subtract background interference according to the condition, i.e.

$$F^{-1}[E_r(x,y)\cdot C_d(x,y,-d_0)] - F^{-1}[E_{rb}(x,y)\cdot C_d(x,y,-d_0)];$$

Select amplitude and display (the image estimation equation (11)). Proceed with other image treatments such as image intensifying, pseudo-color transformation and other changes. Determine the actual size of the image through scaling and estimate certain parameters. (The conversion coefficients between the linear display scale and the actual scale are $K_{r\xi}=\lambda d_0/C_p d_s$ and $K_{r\eta}=\lambda d_0/d_p d_s$)。 Figure 7 shows the block diagram of the estimation method.

Figure 7. Algorithm if Target Estimation by Ultrasonic Holography



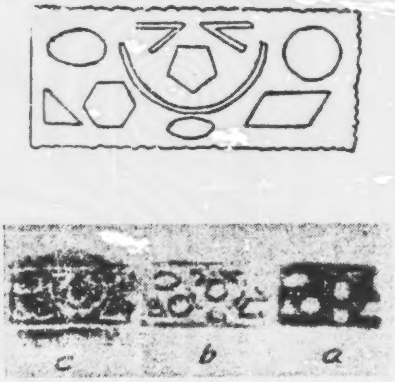
III. Experiment

An ultrasonic holographic imaging system was built according to the theory and algorithm discussed above. An aluminum plate, a plastic template and a fish were used as targets to be tested in the experimental pool. In addition to the aluminum plate shown in Figure 4(c), other results are shown in Figures 8-9. Results indicate that estimated images are very close to the real targets and sizes are also very accurate.

It should be pointed out that in addition to theoretical analysis, optimization of a series of parameters in the experiment is also responsible for obtaining clear images shown above. Otherwise, theoretical conditions established above will be destroyed.

Figure 8. Plastic Template (upper) and Its Estimated Image (lower)

a. target and background interference
b. edge intensification
c. estimated image



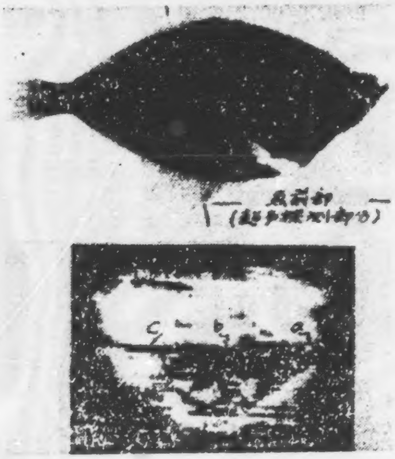


Figure 9. Front Part of a Fish (upper) and Its Estimated Image (lower)

←

a. mouth
b. gill
c. spine

Acknowledgement. The authors wish to thank Professor P.A. Matthews of Leeds University in England and Professor A.P. Anderson of Sheffield University in England for their assistance in this study. They also wish to thank Dr. T. Whittka for his assistance in performing the experimental work.

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12553/8918
CSO: 4008/1066

STATUS OF CHINA'S NUCLEAR S&T RECAPPED

Harbin HEILONGJIANG RIBAO in Chinese 31 Oct 85 p 1

[Article by Zhuo Peirong [0587 1014 2837]]

[Text] Beijing, 30 Oct (XINHUA)--China's nuclear industry has experienced continuous growth since 1955, and its achievements have attracted world attention. A few days ago an official of the Ministry of Nuclear Industry gave a presentation to the reporters outlining the major accomplishments of China's nuclear industry during the past three decades.

--Acquisition of the technologies to develop atomic bombs, hydrogen bombs, and power plants used in nuclear submarines. China has armed its military units with nuclear weapons; the development of nuclear weapons has enhanced China's defensive strength and has been a major factor in protecting the security of this country and maintaining world peace.

--Establishment of a firm foundation in nuclear technology and a comprehensive, nuclear industrial system. This system includes organizations devoted to uranium exploration, mining and processing as well as recycling of nuclear fuel, manufacturing of nuclear weapons, and the peaceful use of nuclear energy and nuclear technology. The development of nuclear science has created many new scientific disciplines, new technologies and new industries such as nuclear medicine, nuclear agriculture and new industries such as nuclear medicine, nuclear agriculture, nuclear environmental protection, nuclear analysis and measurement techniques, nuclear display and tracking techniques, nuclear automatic control technology, nuclear radiation processing industry, and nuclear electronic instrument manufacturing industry; a number of these technologies have already been successfully implemented in various applications.

--Development of China's uranium resources and establishment of technical service facilities for uranium products and other related products. China has already accumulated a sizable reserve of atomic fuel for nuclear power plants and a reserve of uranium products. The instrument manufacturing capability, engineering design capability and construction/installation capability of the nuclear industry have been extensively used in non-nuclear applications.

--Establishment of a firm foundation in nuclear power generation. Currently China has 10 nuclear reactors of various types, and has accumulated considerable operational experience. The Chinshan nuclear power plant project in Zhejiang Province is making good progress, and efforts have been initiated in the theoretical resource of nuclear power plants for heat generation.

--Training a team of highly qualified technical personnel for the nuclear industry.

This official said that China's nuclear industry is following the current trend both in this country and abroad to redirect its energy for economic construction. In recent years, the demands of China's economic and social development have supplied constant challenges to the nuclear industry. With increasing public awareness about nuclear technology, it will undoubtedly play an increasing role in the lives of the Chinese people.

3012/9274
CSO: 4008/39

COUPLING PROPERTIES OF SLOTTED ANTENNA STUDIED

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 92-101

[Article by Lu Shanwei [0712 0810 0251], Ren Jishi [0117 3444 2514], and Fang Yin [2455 1944], Beijing Institute of Aeronautics and Astronautics: "Study of Coupling Properties of Slotted Antenna in a Rectangular Waveguide"]

[Text] Text of English Abstract: Coupling properties of any two longitudinal slots in the wider walls of a rectangular waveguide are analyzed. The theoretical results are in good agreement with the experimental results and with the data previously obtained (for single slot and half-wavelength slots). Based on the calculated and the experimental results, the electric field distribution at the aperture surface, the admittance, the resonant conductance, and the resonant length of the slots are discussed, taking into account both the effects of external and internal mutual coupling between the slots. The effects of the waveguide wall thickness and narrow-side width are also discussed.

I. Introduction

There are great difficulties in calculating quantitatively the mutual coupling effect between slots in a slotted antenna array, thus design of slotted arrays in the 1950's and 1960's was basically based on isolated slot impedance theory[1-3]. Document [4] analyzed the coupling characteristics of two longitudinal half-wave slots on the wide-side of the waveguide but did not give engineering equations of the coupling characteristics of half waveguide wave length slots of the customary distance for situations in which the slot length is fixed and the wall thickness is zero. Documents [5,6, and 7] used the moments method to begin analyzing the characteristics of single slots by solving the problem of electromagnetic field boundary values and obtained a solution with a certain precision. On the basis of the duality principle, documents [8 and 9] used a known vibrator mutual coupling system to compute the mutual coupling of a slot on the outside of the waveguide, and although they obtained excellent experimental results, they still did not take into consideration the mutual coupling effect on the inside of the waveguide. Recent articles[10,11] are similar. By proceeding from constructing a strict mathematical model and solving the problem of boundary values, this paper attempts, on the foundation work of earlier people, to use the Galer Kin's method to analyze the coupling characteristics of two slots on the waveguide wide-side having a definite thickness, any position and the same and different dimensions. The paper deduces theoretically two slots of different dimensions, and at the time of numerical computation and experimentation, selected a typical situation of identical dimensions and the results are still universal. Separately taking and not taking into account mutual coupling, we computed the slot aperature field distribution, scattering parameters, and the relationship of equivalent admittance and slot length, shift, waveguide dimensions and wall thickness and frequency. The theoretical calculations and experimental results are rather uniform.

II. Theory

1. Setting Up Integral Equations

The slotted antenna structure and its coordinate system are illustrated in Figure 1. Hypotheses: (1) the waveguide extends along the z axis towards positive and negative infinity; (2) the thickness of the waveguide walls is the ideal semiconductor of T, the slots are located on an indefinitely large conducting surface; (3) the narrow slot's length/width$\geq$10; (4) the slot is excited by an H_{10} wave from the negative z direction and only H_{10} waves are transmitted in the waveguide.

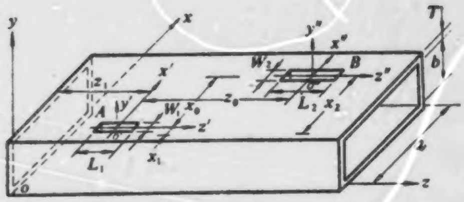


Figure 1. Diagram of slot structure and coordinates

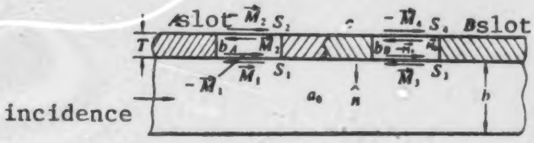


Figure 2. Diagram of partitioned and equivalent magnetic flow

a_o is the inner region of the waveguide; b_A is the A region of the cavity; b_B is the B region of the cavity; c is the half-space region; $M_k=E_k x\hat{n}$, k=1,2,3,4; S_k is the slot aperture at M_k.

From the principle of equivalency, we can use an ideal conducting plate to divide the slotted antenna structure in Figure 1 into four regions: waveguide, cavities A and B, and half-space, as illustrated in Figure 2.

From the continuity of the tangential component of the magnetic field at the slot apertures we can obtain the following integral equation groups:

$$\frac{1}{j\omega\mu}\left(k^2+\frac{d^2}{dz^2}\right)\Big\{\iint_{S_1}(-M_1)[G_a^{zz}(r,r')+G_{bA}^{zz}(r,r')]dS_1' + \iint_{S_2}M_2G_{bA}^{zz}(r,r')\,dS_2' + \iint_{S_3}(-M_3)G_a^{zz}(r,r')dS_3' + 0\Big\} = H_{iA} \quad \text{(r on } S_1 \text{ surface)} \quad (1)$$

$$\frac{1}{j\omega\mu}\left(k^2+\frac{d^2}{dz^2}\right)\Big\{\iint_{S_1}M_1G_{bA}^{zz}(r,r')dS_1' + \iint_{S_2}(-M_2)[G_{bB}^{zz}(r,r')+G_c^{zz}(r,r')]dS_2' + 0 + \iint_{S_4}(-M_4)G_c^{zz}(r,r')dS_4'\Big\} = 0 \quad \text{(r on } S_2 \text{ surface)} \quad (2)$$

$$\frac{1}{j\omega\mu}\left(k^2+\frac{d^2}{dz^2}\right)\Big\{\iint_{S_1}(-M_1)G_a^{zz}(r,r')dS_1' + 0 + \iint_{S_3}(-M_3)[G_a^{zz}(r,r')+G_{bB}^{zz}(r,r')]dS_3' + \iint_{S_4}M_4G_{bB}^{zz}(r,r')dS_4'\Big\} = H_{iB} \quad \text{(r on } S_3 \text{ surface)} \quad (3)$$

$$\frac{1}{j\omega\mu}\left(k^2+\frac{d^2}{dz^2}\right)\Big\{0 + \iint_{S_2}(-M_2)G_c^{zz}(r,r')dS_2' + \iint_{S_3}M_3G_{bB}^{zz}(r,r')dS_3' + \iint_{S_4}(-M_4)[G_{bB}^{zz}(r,r')+G_c^{zz}(r,r')]dS_4'\Big\} = 0 \quad \text{(r on } S_4 \text{ surface)} \quad (4)$$

in which: G_a^{zz} is the $\hat{z}\hat{z}$ component of the dyad potential Green function $\bar{\bar{G}}_a$ of the waveguide; G_b^{zz} is the $\hat{z}\hat{z}$ component of the dyad potential Green function $\bar{\bar{G}}_b$ of the cavity; G_c^{zz} is the $\hat{z}\hat{z}$ component of the dyad potential Green function $\bar{\bar{G}}_c$ of the half-space; r' is at each magnetic flow source; $k^2=W^2\varepsilon\mu$

The wave motion equation which the Green function of each region satisfies and the boundary conditions which satisfy on the metallic surface are respectively:

$$\nabla^2\bar{\bar{G}}(r,r')+k^2\bar{\bar{G}}(r,r') = -\bar{\bar{I}}\delta(r,r') \qquad (5)$$

$$\hat{n}\times\nabla\times\bar{\bar{G}}(r,r')=0, \qquad \hat{n}\cdot\bar{\bar{G}}(r,r')=0 \qquad (6)$$

in which $\bar{\bar{I}}$ is the unit dyad, δ is the delta function. We can derive:

$$G_a^{zz}(r,r') = \sum_{\substack{m=0 \\ m \neq n = 0}}^{\infty} \sum_{n=0}^{\infty} \frac{\varepsilon_{om}\varepsilon_{on}}{2jabU_{mn}} \cos\frac{m\pi x'}{a} \cos\frac{m\pi x}{a} \cos\frac{n\pi y'}{b} \cos\frac{n\pi y}{b} e^{-jU_{mn}|z-z'|} \tag{7}$$

in which

$$U_{mn} = \begin{cases} \sqrt{k^2 - \left(\frac{m\pi}{a}\right)^2 - \left(\frac{n\pi}{b}\right)^2}, & k^2 \geqslant \left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 \\ -j\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 - k^2}, & k^2 < \left(\frac{m\pi}{a}\right)^2 + \left(\frac{\pi n}{b}\right)^2 \end{cases} \tag{8}$$

$$G_b^{zz}(r,r') = -\sum_{l=0}^{\infty}\sum_{m=1}^{\infty}\sum_{n=0}^{\infty} \frac{2\varepsilon_{ol}\varepsilon_{on}}{WLT\left[k^2 - \left(\frac{\pi l}{W}\right)^2 - \left(\frac{m\pi}{L}\right)^2 - \left(\frac{\pi n}{T}\right)^2\right]}$$
$$\cdot \frac{l\pi\left(x' + \frac{W}{2}\right)}{W} \cos\frac{l\pi\left(x + \frac{W}{2}\right)}{W} \sin\frac{m\pi\left(z' + \frac{L}{2}\right)}{L} \sin\frac{m\pi\left(z + \frac{L}{2}\right)}{L}$$
$$\cdot \cos\frac{n\pi\left(y' + \frac{T}{2}\right)}{T} \cos\frac{n\pi\left(y + \frac{T}{2}\right)}{T} \tag{9}$$

the point of origin of the coordinates is located at the center of the cavity; in Eqs. (7) and (9)

$$\varepsilon_{ol,m,n} = \begin{cases} 1, & l,\ m,\ n = 0 \\ 2, & l,\ m,\ n \neq 0 \end{cases} \tag{10}$$

$$G_c^{zz}(r,r') = \exp[-jk|r-r'|]/2\pi|r-r'| \tag{11}$$

2. Deriving the Integral Equations

For convenience, we introduced the following operators:

$$\left.\begin{aligned}
L_{11}&=\frac{1}{j\omega u}\left(k^2+\frac{d^2}{dz^2}\right)\iint_{S_1}-[G_a^{zz}(r,r')+G_{bA}^{zz}(r,r')]dS_1'\\
L_{12}&=\frac{1}{j\omega u}\left(k^2+\frac{d^2}{dz^2}\right)\iint_{S_2}G_{bA}^{zz}(r,r')dS_2'\\
L_{13}&=\frac{1}{j\omega u}\left(k^2+\frac{d^2}{dz^2}\right)\iint_{S_3}-G_a^{z\prime}(r,r')dS_3'\\
L_{14}&=0
\end{aligned}\right\}\quad \text{r on surface } S_1 \tag{12}$$

$$\left.\begin{aligned}
L_{21}&=\frac{1}{j\omega u}\left(k^2+\frac{d^2}{dz^2}\right)\iint_{S_1}G_{bA}^{zz}(r,r')dS_1'\\
L_{22}&=\frac{1}{j\omega u}\left(k^2+\frac{d^2}{dz^2}\right)\iint_{S_2}-[G_{bA}^{zz}(r,r')+G_c^{zz}(r,r')]dS_2'\\
L_{23}&=0\\
L_{24}&=\frac{1}{j\omega u}\left(k^2+\frac{d^2}{dz^2}\right)\iint_{S_4}-G_c^{zz}(r,r')dS_4'
\end{aligned}\right\}\quad \text{r on surface } S_2 \tag{13}$$

$$\left.\begin{aligned}
L_{31}&=\frac{1}{j\omega u}\left(k^2+\frac{d^2}{dz^2}\right)\iint_{S_1}-G_a^{zz}(r,r')dS_1'\\
L_{32}&=0\\
L_{33}&=\frac{1}{j\omega u}\left(k^2+\frac{d^2}{dz^2}\right)\iint_{S_3}-[G_a^{zz}(r,r')+G_{bB}^{zz}(r,r')]dS_3'\\
L_{34}&=\frac{1}{j\omega u}\left(k^2+\frac{d^2}{dz^2}\right)\iint_{S_4}G_{bB}^{zz}(r,r')dS_4'
\end{aligned}\right\}\quad \text{r on surface } S_3 \tag{14}$$

$$\left.\begin{aligned}
L_{41}&=0\\
L_{42}&=\frac{1}{j\omega u}\left(k^2+\frac{d^2}{dz^2}\right)\iint_{S_2}-G_c^{zz}(r,r')dS_2'\\
L_{43}&=\frac{1}{j\omega u}\left(k^2+\frac{d^2}{dz^2}\right)\iint_{S_3}G_{bB}^{zz}(r,r')dS_3'\\
L_{44}&=\frac{1}{j\omega u}\left(k^2+\frac{d^2}{dz^2}\right)\iint_{S_4}-[G_{bB}^{zz}(r,r')+G_c^{zz}(r,r')]dS_4'
\end{aligned}\right\}\quad \text{r on surface } S_4 \tag{15}$$

then Eqs. (1-4) can be written:

$$L_{11}M_1+L_{12}M_2+L_{13}M_3+L_{14}M_4=H_{iA}(r), \qquad \text{(r on surface } S_1\text{)} \tag{16}$$
$$L_{21}M_1+L_{22}M_2+L_{23}M_3+L_{24}M_4=0, \qquad \text{(r on surface } S_2\text{)} \tag{17}$$
$$L_{31}M_1+L_{32}M_2+L_{33}M_3+L_{34}M_4=H_{iB}(r), \qquad \text{(r on surface } S_3\text{)} \tag{18}$$
$$L_{41}M_1+L_{42}M_2+L_{43}M_3+L_{44}M_4=0, \qquad \text{(r on surface } S_4\text{)} \tag{19}$$

the boundary conditions which satisfy M_k, K=1,2,3,4 is

$$M_1|_{z'=\pm L_1/2}=M_2|_{z'=\pm L_1/2}=M_3|_{z'=\pm L_2/2}=M_4|_{z'=\pm L_2/2}=0 \tag{20}$$

Eqs. (16)-(19) combine with boundary condition Eq. (20) for form the dingjie [1353 6043] problem of M_k.

We supposed $f_s^{(k)}$ (s=1,2,....∞) is a complete normal function system within the definition of operator L_{kk}, M_k can be approximated by N linearly unrelated $f_s^{(k)}$ linear groups:

$$M_K=\sum_{s=1}^{N} a_s^{(K)} f_s^{(K)}(r), \qquad r'\in S_K \tag{21}$$

In addition, we took a complete function system $f_i^{(K)}(r)(i=1,2,\cdots\cdots,\infty)$, $r\in S_K$, termed a weight function and defined the inner product as:

$$\langle f_i,\ f_s\rangle_{S_K}=\iint_{S_K} f_i f_s \, dS_K \tag{22}$$

Substituting Eq. (21) in Eqs. (16)-(19), multiplying both sides of the equality by $f_i^{(k)}$ (i=1,2,...,.N) and taking the inner product defined by Eq. (22), then Eqs. (16)-(19) can be changed into matrix equations of the following form:

$$\begin{bmatrix} [A] & [B] & [C] & [D] \\ [E] & [F] & [G] & [H] \\ [K] & [L] & [M] & [N] \\ [O] & [P] & [Q] & [R] \end{bmatrix} \begin{bmatrix} [a^{(1)}] \\ [a^{(2)}] \\ [a^{(3)}] \\ [a^{(4)}] \end{bmatrix} = \begin{bmatrix} [k^A] \\ [0] \\ [k^B] \\ [0] \end{bmatrix} \tag{23}$$

The square matrix on the left in the above equation is a 4Nx4N order matrix, in which [A]-[R] are NxN order sub-matrices, called the admittance matrix; $[h^A]$ and $[h^B]$ are N order column subarrays, called the current matrix. [C] and [K] sub-matrices represent the inner mutual coupling, [H] and [P] represent outer mutual coupling. The elements in the admittance and current matrices are, respectively:

$$\begin{array}{ll}
A_{is}=\langle L_{11}f_s^{(1)},\ f_i^{(1)}\rangle_{s1}, & B_{is}=\langle L_{12}f_s^{(2)},\ f_i^{(1)}\rangle_{s1} \\
C_{is}=\langle L_{13}f_s^{(3)},\ f_i^{(1)}\rangle_{s1}, & D_{is}=0 \\
E_{is}=\langle L_{21}f_s^{(1)},\ f_i^{(2)}\rangle_{s2}, & F_{is}=\langle L_{22}f_s^{(2)},\ f_i^{(2)}\rangle_{s2} \\
G_{is}=0 & H_{is}=\langle L_{24}f_s^{(4)},\ f_i^{(2)}\rangle_{s2} \\
K_{is}=\langle L_{31}f_s^{(1)},\ f_i^{(3)}\rangle_{s3}, & L_{is}=0 \\
M_{is}=\langle L_{33}f_s^{(3)},\ f_i^{(3)}\rangle_{s3}, & N_{is}=\langle L_{34}f_s^{(4)},\ f_i^{(3)}\rangle_{s3} \\
O_{is}=0, & P_{is}=\langle L_{42}f_s^{(2)},\ f_i^{(4)}\rangle_{s4} \\
Q_{is}=\langle L_{43}f_s^{(3)},\ f_i^{(4)}\rangle_{s4}, & R_{is}=\langle L_{44}f_s^{(4)},\ f_i^{(4)}\rangle_{s4} \\
h_i^A=\langle H_{iA},\ f_i^{(1)}\rangle_{s1}, & h_{is}=\langle H_{iB},\ f_i^{(3)}\rangle_{s3}
\end{array} \qquad (24)$$

By the reciprocity theorem it is easy to prove:

$$B_{is}=E_{is},\quad C_{is}=K_{is},\quad H_{is}=P_{is},\quad N_{is}=Q_{is} \qquad (25)$$

$[a^{(1)}]$-$[a^{(4)}]$ is the voltage coefficient matrix which is to be found. Select the appropriate N[13] on the basis of the precision required and after finding the matrix elements using Eq. (24), the coefficient $a_s^{(k)}$ can be found by inversion using Eq. (23). Thus the problem comes down to finding the inner product showed in Eq. (24).

Processing the inner product is complex and time consuming, and because it would take too long, here we give the results after detailed derivation.

Using the Galer Kin's method, we take the base and weight function of each aperture as:

$$f_s^{(1)}=f_s^{(2)}=\sin\frac{s\pi(\eta'+L_1/2)}{L_1}, \qquad -\frac{L_1}{2}\leqslant\eta'\leqslant\frac{L_1}{2} \qquad (26)$$

$$f_s^{(3)}=f_s^{(4)}=\sin\frac{s\pi(\eta''+L_2/2)}{L_2}, \qquad -\frac{L_2}{2}\leqslant\eta''\leqslant\frac{L_2}{2} \qquad (27)$$

$$f_i^{(1)}=f_i^{(2)}=\sin\frac{i\pi(z'+L_1/2)}{L_1}, \qquad -\frac{L_1}{2}\leqslant z'\leqslant\frac{L_1}{2} \qquad (28)$$

$$f_i^{(3)}=f_i^{(4)}=\sin\frac{i\pi(z''+L_2/2)}{L_2}, \qquad -\frac{L_2}{2}\leqslant z''\leqslant\frac{L_2}{2} \qquad (29)$$

Below we give the results of the inner products of each region in sequence, i.e., the specific expression for each element in the admittance matrix.

(1) inner products of the admittance region A_{isa}, M_{isa}, and C_{is}, respectively are:

$$A_{isa} = \langle L_{11} f_s^{(1)},\ f_i^{(1)} \rangle_{s_1} = \begin{cases} \dfrac{W_1^2}{2ab\omega u}\displaystyle\sum_{m=0}^{\infty} e_{om}\left[\frac{\sin(\alpha W_1/2)}{\alpha W_1/2}\cos\alpha x_1\right]^2 \Big\{[\delta_{mo}-(k^2-s^2\xi^2)\gamma(m)] \\ \quad \cdot jL_1\delta_{is} + \displaystyle\sum_{n=0}^{\infty} e_{on}\frac{2si\xi^2}{U_{mn}[s^2\xi^2-U_{mn}^2]}\,\frac{\alpha^2-\beta^2}{i^2\xi^2-U_{mn}^2} \\ \quad \cdot [1-(-1)^i e^{-jU_{mn}L_1}]\Big\}, & i+s=\text{even} \\ 0, & i+s=\text{odd} \end{cases} \tag{30}$$

in which: $\alpha=m\pi/a,\quad \beta=n\pi/b,\quad \xi=\pi/L_1,\quad n\neq m=0$

$$\delta_{is}=\begin{cases}1, & i=s\\ 0, & i\neq s\end{cases},\qquad \delta_{mo}=\begin{cases}1, & m=0\\ 0, & m\neq 0\end{cases} \tag{31}$$

$$\gamma(m)=\frac{b}{\sqrt{k^2-s^2\xi^2-\alpha^2}}\cot b\sqrt{k^2-s^2\xi^2-\alpha^2} \tag{32}$$

$$C_{is}=\langle L_{13} f_s^{(3)},\ f_i^{(1)}\rangle_{s_1}=\frac{W_1W_2}{2ab\omega u}\sum_{\substack{m=0\\ m\neq n=0}}^{\infty}\sum_{n=0}^{\infty}\frac{e_{om}e_{on}}{U_{mn}}$$

$$\cdot\frac{\sin(\alpha W_1/2)}{\alpha W_1/2}\,\frac{\sin(\alpha W_2/2)}{\alpha W_2/2}\cos\alpha x_1\cos\alpha x_2\cdot\begin{cases}\Xi_1\\ \Xi_2\end{cases} \tag{33}$$

in which: $\Xi_1=(\alpha^2+\beta^2)\dfrac{\zeta}{\zeta^2-U_{mn}^2}\,\dfrac{i\xi}{i^2\xi^2-U_{mn}^2}e^{-jU_{mn}z_0}[e^{jU_{mn}L_2/2}-(-1)^s e^{-jU_{mn}L_2/2}]$

$$\cdot[e^{-jU_{mn}L_1/2}-(-1)^i e^{jU_{mn}L_1/2}],\qquad (L_1/2)+(L_2/2)\leqslant z_0$$

$$\Xi_2=(\alpha^2+\beta^2)\frac{\zeta}{\zeta^2-U_{mn}^2}\,\frac{i\xi}{i^2\xi^2-U_{mn}^2}[e^{-jU_{mn}(z_0-L_2/2+L_1/2)}-(-1)^s e^{-jU_{mn}(z_0+L_2/2+L_1/2)}$$

$$+(-1)^{i+s}e^{-jU_{mn}(z_0+L_2/2+L_1/2)}-(-1)^i e^{jU_{mn}(z_0-L_2/2-L_1/2)}]+jU_{mn}\cdot\begin{cases}\Lambda_1 & (33a)\\ \Lambda_2 & (33b)\end{cases}$$

in which: $\zeta = s\pi/L_2,\ A_1 = \frac{1}{\zeta^2 - U_{mn}^2}\ \frac{1}{i^2\xi^2 - U_{mn}^2}\ \frac{1}{\zeta^2 - i^2\xi^2}\Big\{2\zeta[k^2 - i^2\xi^2]\sin\Big[\Big(\frac{z_0 - L_1/2}{L_1/2} + 1\Big)$
$\cdot\frac{i\pi}{2}\Big][\zeta^2 - U_{mn}^2] - (-1)^{i+s}2i\xi[k^2 - \zeta^2]\sin\Big[\Big(\frac{z_0 - L_1/2}{L_2/2} + 1\Big)\frac{s\pi}{2}\Big][i^2\xi^2 - U_{mn}^2]\Big\},\ i \neq s,$
$L_1 \neq L_2,\ A_2 = \Big\{\frac{2s\pi/2}{(\zeta^2 - U_{mn}^2)^2}(\alpha^2 + \beta^2)\sin\Big(\frac{z_0 - L_2/2}{L_2/2}\ \frac{i\pi}{2}\Big) + \frac{k^2 - \zeta^2}{\zeta^2 - U_{mn}^2}\Big[(L_2 - z_0)\cdot\cos\zeta z_0 +$
$\frac{1}{\zeta}\sin\zeta z_0\Big]\Big\},\qquad i = s,\ L_1 = L_2,\qquad (L_1 + L_2)/2 > z_0$

$$M_{isa} = A_{isa}|_{L_1 = L_2,\ W_1 = W_2,\ z_1 = z_2} \tag{34}$$

(2) Inner products of the cavity region A_{isbA}, B_{isbA}, F_{isbA}, M_{isbA}, R_{isbB} respectively are:

$$A_{isbA} = \langle L_{11} f_i^{(1)},\ f_i^{(1)}\rangle_{s_1} = \frac{1}{j\omega\mu}\ \frac{W_1 L_1}{2}\ \frac{\alpha_A'\cos\alpha_A' T}{\sin\alpha_A' T}\delta_{is} \tag{35}$$

$$B_{is} = \frac{-1}{j\omega\mu}\ \frac{W_1 L_1}{2}\ \frac{\alpha_A'}{\sin\alpha_A' T}\delta_{is},\qquad F_{isbA} = A_{isbA} \tag{36}$$

$$M_{isbA} = R_{isbB} = A_{isbA}|_{L_1 = L_2,\ W_1 = W_2,\ \alpha'_A = \alpha'_B},\ N_{is} = B_{is}|_{L_1 = L_2,\ W_1 = W_2,\ \alpha'_A = \alpha'_B}$$

in which: $\alpha_A' = \sqrt{k^2 - s^2\xi^2},\ \alpha_B' = \alpha_A'|_{L_1 = L_2},\ \delta_{is} = 1(i = s), = 0(i \neq s)$

(3) Inner products of the half-space region H_{is}, F_{isc}, R_{isc} respectively are:

$$\begin{aligned} H_{is} &= \langle L_{2} f_i^{(4)},\ f_i^{(2)}\rangle_{s_2} \qquad\qquad (37)\\ &= \frac{1}{j\omega\mu 16\pi}\Big\{\int_v^{\sigma} A_p \sin\Big[\frac{i\pi}{2}\Big(\frac{2v}{L_1} - 1 + \frac{L_2}{L_1}\Big)\Big]\Big[(-1)^{i+s}f_2(v) + f_2(-v)\Big]dv \\ &\quad + \int_v^{-\sigma} B_p \sin\Big[\frac{s\pi}{2}\Big(\frac{2v}{L_2} - 1 + \frac{L_1}{L_2}\Big)\Big][(-1)^{i+s}f_2(-v) + f_2(v)]dv\Big\},\ \begin{matrix} L_1 \neq L_2 \\ W_1 \neq W_2 \end{matrix} \end{aligned}$$

in which: $\sigma = (L_1 - L_2)/2,\ \nu = -(L_1 + L_2)/2,\ A_p = \frac{2k^2}{\pi\mathscr{L}_+} - \frac{2k^2}{\pi\mathscr{L}_-} - \frac{i\pi\mathscr{L}_-}{L_1\mathscr{L}_+} + \frac{i\pi\mathscr{L}_+}{L_1\mathscr{L}_-},\ B_p$
$= \frac{2k^2}{\pi\mathscr{L}_+} + \frac{2k^2}{\pi\mathscr{L}_-} + \frac{i\pi\mathscr{L}_-}{L_2\mathscr{L}_+} + \frac{i\pi\mathscr{L}_+}{L_2\mathscr{L}_-},\ f_2(v) = \iint_{D'} \frac{\exp[-jk\sqrt{(u' - x_0)^2 + (v - z_0)^2}}{\sqrt{(u' - x_0)^2 - (v - z_0)^2}}\ du'\,du,$

in which: $\mathscr{L}_+=(i/L_1)+(s/L_2),\quad \mathscr{L}_-=(i/L_1)-(s/L_2),$

integral region D' is a sloped rectangular region with the four points--A_o $[(W_1-W_2)/2,\ (W_1+W_2)/2]$, $B_o[-(W_1+W_2)/2,\ (W_2-W_1)/2]$, $C_o[(W_2-W_1)/2,\ -(W_1+W_2)/2]$, $D_o[(W_1+W_2)/2,\ (W_1-W_2)/2]$. If $W_2=W_1=W$, $L_1=L_2=L$, then

$$f(v)=f_2(v)=2\int_0^W(-u+W)\left(\frac{e^{-jkr_1}}{r_1}+\frac{e^{-jkr_2}}{r_2}\right)du$$

in which: $r_1=\sqrt{(u+x_0)^2+(v-z_0)^2},\qquad r_2=\sqrt{(u-x_0)^2+(v-z_0)^2}$

$$F_{i,s,c}=\frac{1}{j\omega\mu\pi}\begin{cases} -\int_0^{L_1}\{[k^2-s^2\xi^2](-v+L_1)\cos s\xi v+([k^2+s^2\xi^2]/s\xi)\sin s\xi v\}g(v)dv, & i=s\\ \int_0^{L_1}\frac{2L_1}{\pi(i^2-s^2)}\{s[k^2-i^2\xi^2]\sin i\xi v-i[k^2-s^2\xi^2] \\ \quad\cdot\sin s\xi v\}g(v)dv, & i+s=\text{even},\ i\neq s\\ 0, & i+s=\text{odd},\ i\neq s \end{cases}\tag{38}$$

in which:
$$\begin{aligned} g(v)=&-j\int_0^{W_1}(-u+W_1)\frac{\sin k\sqrt{u^2+v^2}}{\sqrt{u^2+v^2}}du+\frac{1}{k}(\sin kv-\sin k)\sqrt{W_1^2+v^2}\\ &+W_1\left[\ln\frac{W_1+\sqrt{W_1^2+v^2}}{v}-\int_0^{W_1}\frac{1-\cos k\sqrt{u^2+v^2}}{\sqrt{u^2+v^2}}du\right]\\ R_{i,s,c}=&F_{i,s,c}|_{L_1=L_2,\ W_1=W_2} \end{aligned}\tag{39}$$

Finally we can write the other admittance matrix elements:

$$\left.\begin{aligned} &A_{i,s}=A_{i,s,a}+A_{i,s,bA}, && F_{i,s}=F_{i,s,c}+F_{i,s,bA}(=A_{i,s,bA})\\ &M_{i,s}=M_{i,s,bB}(=R_{i,s,bB})+M_{i,s,a}, && R_{i,s}=R_{i,s,c}+R_{i,s,bB}(=M_{i,s,bB}) \end{aligned}\right\}\tag{40}$$

(4) Inner production of excitation h^A and h^B. Supposing the incident H_{10} wave longitudinal magnetic field component $H_1=A_o\cos(\pi x/a)\cdot e^{-jU10z}$ (in numerical calculations $A_o=1$), then we have

$$\begin{aligned} h_i^A=&\langle H_{iA},\ f_i^{(1)}\rangle_{s1}\\ =&\begin{cases} 2A_0W_1\cos\dfrac{\pi x_1}{a}\ \dfrac{i\xi}{i^2\xi^2-U_{10}^2}\cos\left(\dfrac{L_1}{2}U_{10}\right), & i=\text{odd}\\ j2A_0W_1\cos\dfrac{\pi x_1}{a}\ \dfrac{i\xi}{i^2\xi^2-U_{10}^2}\sin\left(\dfrac{L_1}{2}U_{10}\right), & i=\text{even} \end{cases} \end{aligned}\tag{53}$$

$$h_i^B=\langle H_{iB},\ f_i^{(3)}\rangle_{s3}=h_i^Ae^{-jU_{10}z_0}|_{L_1=L_2,\ W_1=W_2,\ x_1=x_2}\tag{54}$$

$a_s^{(1)}$ and $a_s^{(3)}$ found through the matrix inversely, M_1 and M_2 are known, then their scattering field inside the waveguide can be found and the discontinuities caused by the slots can be described using the equivalent network. Let only H_{10} waves be transmitted in the waveguide, the two reference surfaces selected are in the center of A and B slots, and the observation point is sufficiently far from this foot. Thus from the scattering field we can find the equivalent scattering parameter S, and from the relationship of S and the equivalent admittance Y, find Y, through a certain approximation, Y_A or Y_B can be found[15].

III. Theoretical Calculations and Experimental Results

On the x wave band, specific calculations and experimental research was carried out on two longitudinal slots of equal length spaced $\lambda_g/2$ apart on the same waveguide.

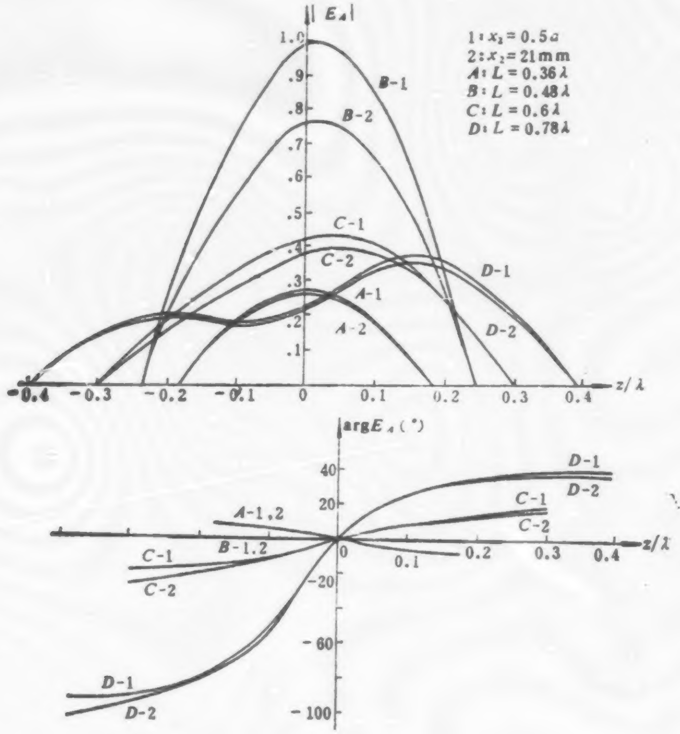


Figure 3. Electrical field distribution tangential to slot A aperture

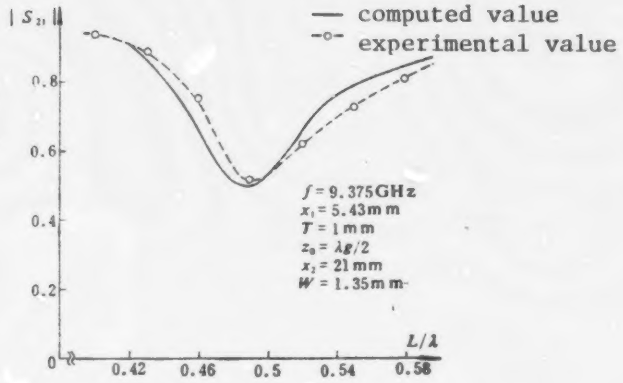


Figure 4. Curve of the relationship of twin slot transmission coefficient $|S_{21}|$ and slot length L ($|S_{21}| = |S_{12}|$)

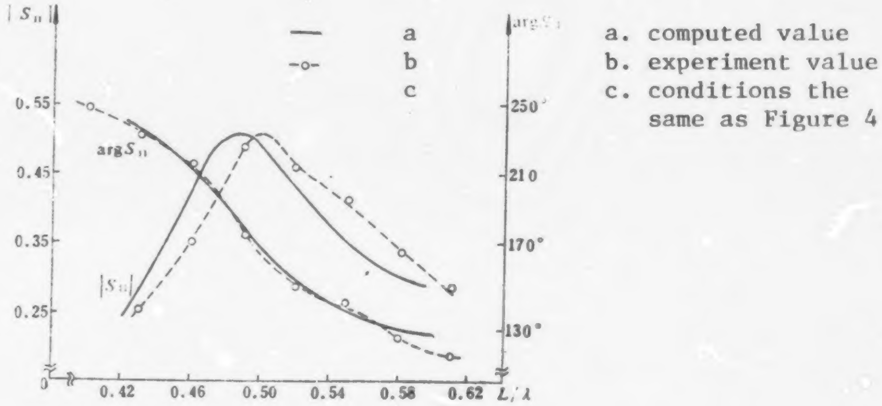
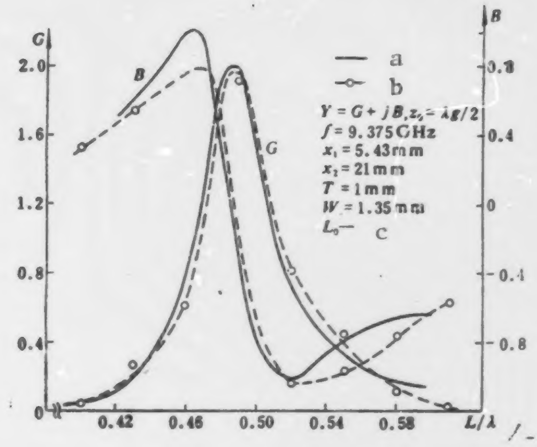


Figure 5. Curve of the relationship of twin slot reflection coefficient $|S_{11}|$ and slot length L



a. computed value
b. experiment value
c. resonant length

Figure 6. Curve of the relationship of twin slot equivalent admittance and slot length L

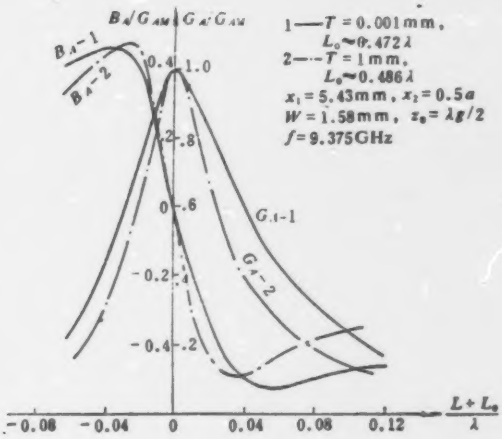


Figure 7. Curve of the relationship of slot A normalized admittance with wall thickness T and slot length L

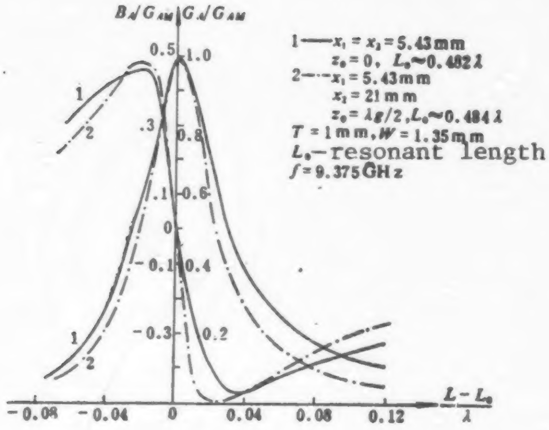


Figure 8. Curve of the relationship of slot A's admittance and slot B's drift

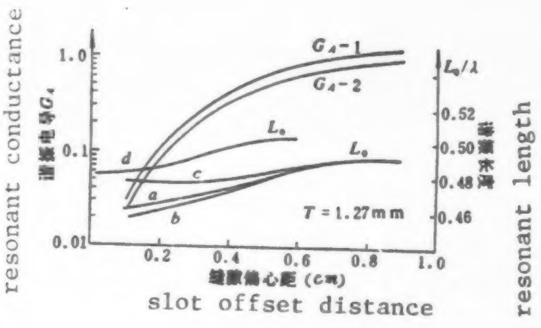
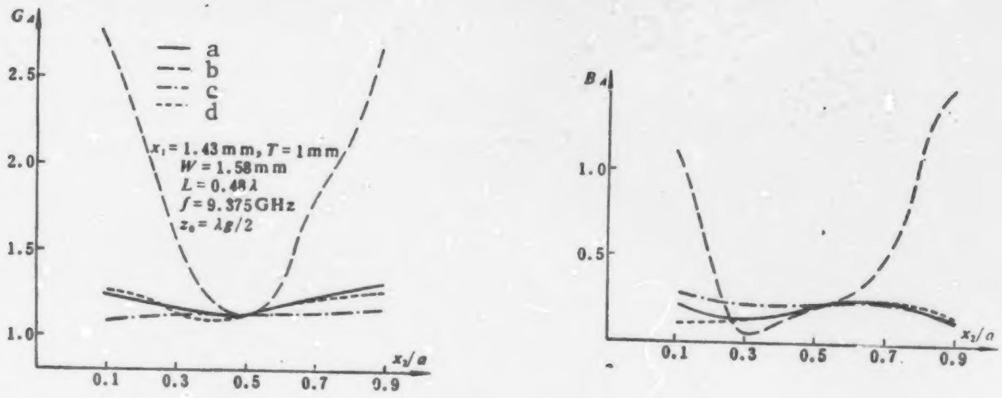


Figure 9. Curve of the relationship of slot A's resonant conductance G_A, resonant length L_0/λ and slot offset distance*

*G_A-1 is the curve (x_2=21mm, $z_0=\lambda g/2$) of the calculation of slot resonance conductance G_A when calculating mutual coupling in this article; G_A-2 is the calculation of an individual slot by this article and documents [1], [5], and [6]. In them, a belongs to [5]; b is this article's calculation of resonance length of an individual slot; c is this article's calculation of the resonance length of slot A when calculating mutual coupling; d is the document [5]'s curve of the resonance length of an individual semi-circular slot.



a. contains coupling effect
b. not counting mutual coupling inside waveguide
c. not counting mutual coupling outside waveguide
d. not counting high order mode coupling inside waveguide

Figure 10. Relationship of slot A conductance when coupling effects are computed and slot B drift

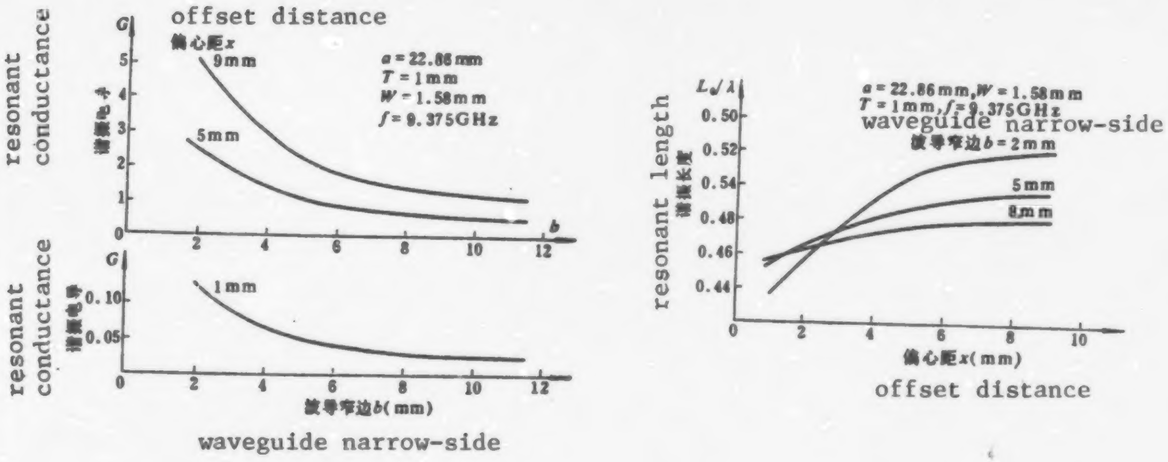


Figure 11. G-b characteristics of independent slot and characteristics of L_0/λ.

Figure 3 is the curve of calculations of the electrical field distribution tangential to the slot aperature surface. When slot length $L<0.5\lambda$, the ratio of the secondary harmonic and the base wave amplitude is less than 0.08, the aperture field can be known as the cosine distribution. The thickness of the waveguide walls plays a decay role in the slot field, but when T=1mm approximately, the influence is not great. The mutual coupling effect diminishes the aperture surface field base wave amplitude and increases the secondary harmonic amplitude.

Figures 4 and 5 are computed and experimental values of S parameter, the two basically fit. We also carried out calculations on the S parameter using the conditions of document [4], the results fit with Kay's[4] experimental values.

Figure 6-8 are the equivalent admittance characteristics of the slots. Figure 7 shows that the waveguide wall thickness narrows the frequency band and increases the length of the resonance. From Figure 8 it can be seen that mutual coupling narrows the frequency band and lengthens the resonance (see Figure 9).

Figure 9 is the curve of the relationship of the resonant conductance and resonant length with the slot's offset distance. Comparing this with the results of document [5], the resonant length difference is about 1 percent, and the resonant conductances are the same. When computing the mutual coupling under the conditions in the note to the figure* the resonant conductance increased.

Figure 10 shows that under the conditions given in this paper, waveguide internal mutual coupling has a clear influence on admittance characteristics: including, primary mode plays an important role, external mutual coupling is next, higher modes are minimal and can even be overlooked. Figure 11 is the relationship between resonant conductance G and resonant length L_0/λ with offset distance x and the dimensions of the waveguide's narrow side b. It can be seen that when x and b are both small, the resonant length is sensitive to offset distance x; at this time it is appropriate to use a larger slot.

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*G_A-1 is the curve (x_2=21mm, $z_0=\lambda g/2$) of the calculation of slot resonance conductance G_A when calculating mutual coupling in this article; C_A-2 is the calculation of an individual slot by this article and documents [1],[5], and [6]. In them, a belongs to [5]; b is this article's calculation of resonance length of an individual slot; c is this article's calculation of the resonance length of slot A when calculating mutual coupling; d is the document [5]'s curve of the resonance length of an individual semi-circular slot.

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APPLIED SCIENCES

RADAR ANTENNA TRANSIENT EFFECTS STUDIED

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 11, No 6, Nov 83 pp 80-87

[Article by Hu Hannan [5170 3352 0589] of Shanghai Ship & Shipping Research Institute: "End-fed Array Antenna Transient Effects and Their Effect on Angular Revolution"*]

[Text] Abstract: The problem of transient effect of one-dimensional end-fed array antennas is discussed. It is shown that the transient effect of end-fed array antennas will deteriorate the angular resolution performance in radar systems, and that such influence is more serious to the radars sensitive to the amplitudes of very short pulses.

Chapter 13 of Skolnik [1] has a concise discussion on the problem of the pulse energy gain function for one-dimensional end-fed array antennas. As for the results produced by constant excitation, that reference also cites the pulse energy directivity graph for constant excitation and cosine excitation produced by the data in Wheeler [2]. This paper studies the transient effects of one-dimensional end-fed array antennas under arbitrary excitation amplitude aperture distribution, as well as discusses functions for antenna instantaneous power gain functions for the maximum value for antenna instantaneous power gain, and relations between those functions and between them and functions for antenna steady state power gain; particular results are produced for the distribution of constant excitation, cosine excitation, and the $I_0(A\sqrt{1-v^2})$ excitation actually often used; finally there is an analysis of the effects of antenna transient effects on angular resolution.

I. The Transient Effects of Arbitrary Excitation

When one-dimensional array antennas receive RF pulse signal excitation, the function for instantaneous power gain is (cf. Figures 21 and 23 in Chapter 13 of reference [1])

$$G_P(\theta, t)=\frac{2\pi WL}{\lambda^2}\frac{\left|\int_{-1}^{2t/T_0}A(v, \omega, t)e^{juv}dv\right|^2}{\int_{-1}^{1}\left|A(v, \omega)\right|^2dv} \qquad (1)$$

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*Received in June 1982, finalized in January 1983.

In the equation, when the RF angular frequency is ω, $A(v,\omega,t)$ is the antenna aperture radiating function for the normalized distance $v=2x/L$ along the direction of the length of the antenna at time t; x is the actual distance where the antenna center is the point of origin; L is the length of the antenna aperture; when the angular frequency is ω, $A(v,\omega)$ is the aperture steady state radiating function at location v; $u=\pi L\sin\theta/\lambda$, θ is the space angle, λ is the RF wavelength; T_a is the time for the RF pulse to be transmitted from one end of the antenna to the other end; W is the width of the antenna aperture.

Under conditions of rectangular RF pulse excitation, let the envelope be $\mathrm{rect}(t/T_r)$, assume that the width is $T_r \gg T_a$, the RF frequency is equal to the antenna center frequency (the steady-state dominant wave beamed toward the normal line), then

$$A(v,\omega,t)=\begin{cases} B(v)\begin{cases} |t|\leqslant T_a/2, & -1\leqslant v\leqslant 2t/T_a \\ T_a/2\leqslant t\leqslant T_r-T_a/2, & |v|\leqslant 1 \\ |t-T_r|\leqslant T_a/2, & 2(t-T_r)/T_a\leqslant v\leqslant 1 \end{cases} \\ 0 \quad \text{the remainder} \end{cases} \tag{2}$$

$$A(v,\omega)=B(v) \qquad |v|\leqslant 1 \tag{3}$$

In this we take the time when the leading edge of the pulse reaches the center of the antenna as the point of origin for t; $B(v)$ is the amplitude distribution for the antenna aperture normalized excitation (this paper only discusses in-phase excitation). Therefore, we can rewrite equation (1) as the product of the antenna steady-state maximum gain G_{max} and the normalized instantaneous power gain function $g_p(\theta,t)$:

$$G_p(\theta,t)=G_{max}g_p(\theta,t) \tag{4}$$

where

$$G_{max}=\frac{2\pi WL}{\lambda^2}\left|\int_{-1}^{1}B(v)dv\right|^2\Big/\int_{-1}^{1}B^2(v)dv \tag{5}$$

$$g_p(\theta,t)=\begin{cases} g_t(\theta,t), & |t|\leqslant T_a/2 \\ g(\theta), & T_a/2\leqslant t\leqslant T_r-T_a/2 \\ g_t(\theta,T_r-t) & |t-T_r|\leqslant T_a/2 \end{cases} \tag{6}$$

in which, $g_t(\theta,t)$ and $g_t(\theta,T_r-t)$ are the transient state portion of $g_p(\theta,t)$; $g(\theta)$ is the steady-state portion, called the normalized steady-state power gain function:

$$g_t(\theta,t)=\frac{\left|\int_{-1}^{\tau}B(v)e^{iuv}\,dv\right|^2}{\left|\int_{-1}^{1}B(v)dv\right|^2}, \quad |\tau|=\left|\frac{2t}{T_a}\right|\leqslant 1 \tag{7}$$

$$g(\theta)=\frac{\left|\int_{-1}^{1}B(v)e^{iuv}\,dv\right|^2}{\left|\int_{-1}^{1}B(v)dv\right|^2}=g_t\left(\theta,\frac{T_a}{2}\right) \tag{8}$$

In the normal direction: g(0)=1

$$g_t(0,t)=\left|\int_{-1}^{\tau} B(v)dv\right|^2 \Big/ \left|\int_{-1}^{1} B(v)dv\right|^2$$

Ordinarily, B(v) is continuous and bounded, and B'(v) and B"(v) are also piecewise bounded, at which time it can be proven that:

$$g_t(\theta,t)\rightarrow\frac{B^2(-1)+B^2(\tau)-2B(-1)B(\tau)\cos(1+\tau)u}{\left|\int_{-1}^{1} B(v)dv\right|^2 u^2}, \quad u\rightarrow\infty \tag{9}$$

In general, B(v) is a paired function, and if at this time there are the properties mentioned above, then

$$g(\theta)\rightarrow\frac{4B^2(1)}{\left|\int_{-1}^{1} B(v)\,dv\right|^2}\,\frac{\sin^2 u}{u^2}, \quad u\rightarrow\infty \tag{10}$$

When the function for the normalized instantaneous power gain maximum value $g_m(\theta)$ is $g_p(\theta,t)$ or $g_t(\theta,t)$ for the maximum value function of t, obviously

$$g_m(\theta)\geqslant g(\theta)$$

Generally, B(v) is the monotonic non-increasing function of |v|, which if at this time it is still a paired function, then we can show:

$$g_m(\theta)=g(\theta), \qquad u\leqslant\pi/2 \tag{11}$$

If B(v) is continuous and bounded, and if there are also piecewise bounded B'(v) and B"(v), and moreover they are monotonic non-increasing functions of |v|, then

$$g_m(\theta)\rightarrow\left[\frac{B(-1)+B(0)}{\int_{-1}^{1} B(v)dv}\right]^2\frac{1}{u^2}, \quad u\rightarrow\infty \tag{12}$$

The pulse energy gain function for one-dimensional end-fed array antennas under RF pulse signal excitation

$$G_t(\theta)=\frac{2\pi WL}{\lambda^2}\,\frac{\int_{-\infty}^{\infty}\left|\int_{-1}^{1} A(v,\omega,t)e^{iuv}dv\right|^2 dt}{\int_{-\infty}^{\infty}\int_{-1}^{1}\left|A(v,\omega,t)\right|^2 dv\,dt} \tag{13}$$

under conditions of rectangular RF pulse excitation (with conditions similar to those above)

$$G_p(\theta)=\frac{2\pi WL}{\lambda^2}\frac{2\int_{-T_e/2}^{T_e/2}\left|\int_{-1}^{2t/T_e}B(v)e^{iuv}dv\right|^2dt+\int_{T_e/2}^{T_s-T_e/2}\left|\int_{-1}^{1}B(v)e^{iuv}dv\right|^2dt}{2\int_{-T_e/2}^{T_e/2}\int_{-1}^{2t/T_e}B^2(v)dvdt+\int_{T_e/2}^{T_s-T_e/2}\int_{-1}^{1}B^2(v)dvdt} \quad (14)●$$

We have already assumed that here B(v) is a paired function, and consequently is equal to the corresponding integration in the buildup and decay times of the antenna excitation. The equation above may be rewritten as

$$G_p(\theta)=G_{max}g_e(\theta) \quad (15)$$

where

$$g_e(\theta)=g(\theta)-\frac{T_e}{T_s}\left[g(\theta)-\int_{-1}^{1}g_t(\theta,\tau)d\tau\right], \quad \frac{T_e}{T_s}<1 \quad (16)$$

is the function for normalized pulse energy gain, in which the first term on the right is the steady-state portion, and the second term is the transient portion. Note that in equation (6) there is

$$g_e(\theta)=\frac{1}{T_s}\int_{-T_e/2}^{T_s+T_e/2}g_p(\theta,t)dt \quad (17)$$

In the normal direction,

$$g_e(0)=1-\frac{T_e}{T_s}\left[1-\int_{-1}^{1}g_t(0,\tau)d\tau\right], \quad \frac{T_e}{T_s}<1 \quad (18)$$

It is easy to prove, if B(v) is a paired function, then g(θ) $g_t(\theta,t)$, $g_p(\theta,t)$, $g_m(\theta)$, $g_e(\theta)$ and $G_p(\theta)$ are all paired functions of θ or u.

II. The Transient Effects of Constant Excitation, Cosine Excitation and $I_0(A\sqrt{1-v^2})$ Excitation

1. Constant Excitation. At this time

$$B(v)=1, \quad |v|<1 \quad (19)$$

$$G_{max}=4\pi WL/\lambda^2 \quad (20)$$

$$g(\theta)=\sin^2u/u^2 \quad (21)$$

$$g_t(\theta,\tau)=\sin^2\left(\frac{1+\tau}{2}u\right)\Big/u^2 \quad (22)$$

$$g_m(\theta)=\begin{cases}\sin^2u/u^2, & u<\pi/2\\ 1/u^2, & u>\pi/2\end{cases} \quad (23)$$

That is, when $u<\pi/2$, $g_m(\theta)=g(\theta)$; when $u>\pi/2$, $g_m(\theta)$ is the envelope of $g_m(\theta)$;

● In reference [1]: Eq. (29) of Chapter 13 is in error.

$$g_e(\theta)=\frac{\sin^2 u}{u^2}-\frac{T_a}{T_s}\left[\frac{\sin^2 u}{u^2}-\frac{1}{u^2}\left(1-\frac{\sin 2u}{2u}\right)\right],\quad \frac{T_a}{T_s}<1 \qquad (24)●$$

In the normal direction,

$$g_e(0)=1-\frac{1}{3}\frac{T_a}{T_s},\quad \frac{T_a}{T_s}<1 \qquad (25)$$

When $u\to\infty$

$$g_e(\theta)\to\frac{\sin^2 u}{u^2}+\frac{T_a}{T_s}\frac{\cos^2 u}{u^2},\quad \frac{T_a}{T_s}<1 \qquad (26)$$

Figure 1 is a graph of $g_p(\theta,t)$ during buildup time and partial steady-state times when values of u are different, and Figure 2 is a graph of $g_e(\theta)$ for u when $g(\theta)$, $g_m(\theta)$, and there are different values for T_a/T_s.

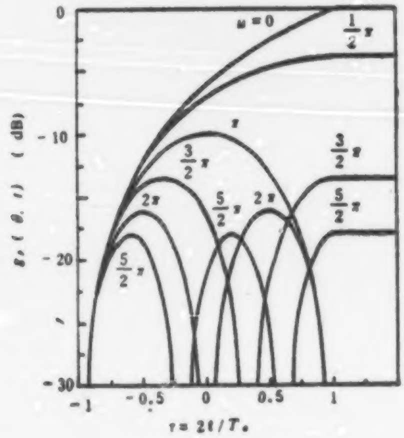

Figure 1. $g_p(\theta,t)$ for constant excitation

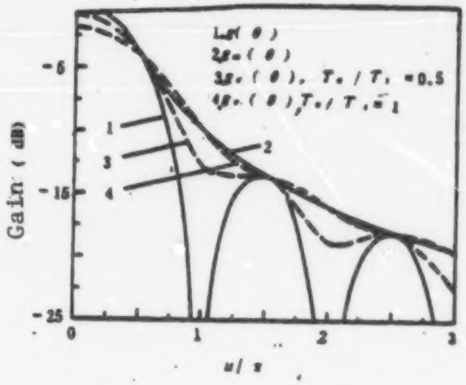

Figure 2. $g(\theta)$, $g_m(\theta)$ and $g_e(\theta)$ for constant excitation

2. Cosine Excitation. At this time

$$B(v)=\cos\frac{\pi}{2}v,\quad |v|<1 \qquad (27)$$

$$G_{\max}=\frac{8}{\pi^2}\frac{4\pi WL}{\lambda^2} \qquad (28)$$

● In reference [1]: Eq. (30) of Chapter 13 is in error. Also,
In reference [3]: Eq. (2.57) is in error.

$$g(\theta) = \cos^2 u/\xi^2 \qquad (29)$$

in which

$$\xi = 1 - 4u^2/\pi^2$$

$$g_p(\theta, t) = \frac{1 + \sin^2\frac{\pi}{2}\tau + \frac{4u^2}{\pi^2}\cos^2\frac{\pi}{2}\tau}{4\xi^2} + \frac{2\cos(1+\tau)u\sin\frac{\pi}{2}\tau - \frac{4u}{\pi}\sin(1+\tau)u\cos\frac{\pi}{2}\tau}{4\xi^2} \qquad (30)$$

$$g_m(\theta)\begin{cases} = \cos^2 u/\xi^2, & u \leqslant \pi/2 \\ \to \pi^2/16u^2, & u \to \infty \end{cases} \qquad (31)$$

$$g_e(\theta) = \frac{\cos^2 u}{\xi^2} - \frac{T_a}{T_p}\left[\frac{\cos^2 u}{\xi^2} + \frac{4u\sin 2u}{\pi^2\xi^3} - \frac{0.75 + u^2/\pi^2}{\xi^2}\right] \qquad (32)$$

In the normal direction

$$g_e(0) = 1 - (T_a/4T_p), \qquad T_a/T_p \leqslant 1 \qquad (33)$$

When $u \to \infty$

$$g_e(\theta) \to \frac{T_a}{T_p}\frac{\pi^2}{16u^2}, \qquad T_a/T_p \leqslant 1 \qquad (34)$$

See Figure 3 for the graph of $g_p(\theta,t)$, and see Figure 4 for the graphs of $g(\theta)$, $g_m(\theta)$, and $g_e(\theta)$.

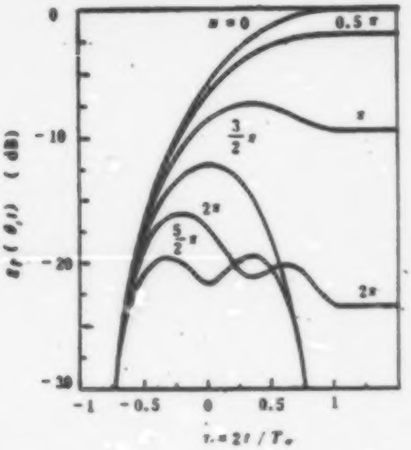

Figure 3. $g_p(\theta,t)$ for cosine excitation

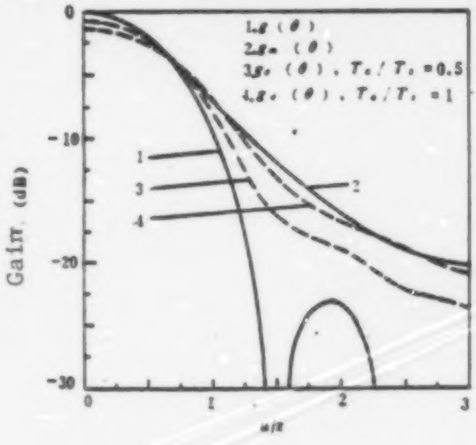

Figure 4. $g(\theta)$, $g_m(\theta)$, and $g_e(\theta)$

3. $I_0(A\sqrt{1-v^2})$ Excitation. At this time

$$B(v)=\frac{1}{2}I_0\left(A\sqrt{1-v^2}\right), \qquad |v|\leqslant 1 \tag{35}$$

$$g(\theta)=\frac{A^2}{\sin h^2 A}\frac{\sin^2\sqrt{u^2-A^2}}{u^2-A^2} \tag{36}$$

But it is difficult to obtain an accurate expression for G_{max}, $g_t(\theta,t)$, g_m(theta), and $g_e(\theta)$. Consequently, equation (35) can be more or less approximated with the following simple periodic excitation[•]

$$B^*(v)=a+b\cos cv, \qquad |v|\leqslant 1 \tag{37}$$

in which

$$\left.\begin{aligned} &c=2\arccos\left[\frac{1}{2}\frac{B(0)-B(1)}{B(0)-B(\frac{1}{2})}-1\right] \\ &b=\frac{B(0)-B(1)}{1-\cos c}, \qquad a=B(0)-b \end{aligned}\right\} \tag{38}$$

We can point out at the same time that constant excitation, cosine excitation, and cosine square excitation are all examples of this kind of simple periodic excitation; they may also be used for approximations of multi-type excitation. Using the approximation excitation formula (37) we can obtain approximation expressions for G_{max}, $g(\theta)$, $g_t(\theta,t)$, $g_m(\theta)$, and $g_e(\theta)$:

$$G^*_{max}=\frac{\left(a+b\frac{\sin c}{c}\right)^2}{a^2+2ab\frac{\sin c}{c}+\frac{b^2}{2}\left(1+\frac{\sin 2c}{2c}\right)}\frac{4\pi WL}{\lambda^2} \tag{39}$$

$$g^*(\theta)=\left[\frac{a\frac{\sin u}{u}+b\frac{u\sin u\cos c-c\sin c\cos u}{u^2-c^2}}{a+b\frac{\sin c}{c}}\right]^2 \tag{40}$$

$$\begin{aligned} g^*_t(\theta,t)=&\frac{1}{4}\left(a+b\frac{\sin c}{c}\right)^2 \\ &\times\left\{\left[a\frac{\sin u+\sin u\tau}{u}+b\frac{u(\sin u\cos c+\sin u\tau\cos c\tau)-c(\cos u\sin c+\cos u\tau\sin c\tau)}{u^2-c^2}\right]^2\right. \\ &+\left.\left[a\frac{\cos u-\cos u\tau}{u}+b\frac{u(\cos u\cos c-\cos u\tau\cos c\tau)+c(\sin u\sin c-\sin u\tau\sin c\tau)}{u^2-c^2}\right]^2\right\} \end{aligned} \tag{41}$$

$$g^*_m(\theta)\begin{cases} =g^*(\theta), & u\leqslant\pi/2 \\ \longrightarrow\left[\dfrac{a+\frac{b}{2}(1+\cos c)}{a+b\frac{\sin c}{c}}\right]^2\dfrac{1}{u^2}, & u\to\infty \end{cases} \tag{42}$$

[•] Corresponding symbols are all distinguished by the addition of an "*."

$$\int_{-1}^{1} g_e^*(\theta, t)\,d\tau = \frac{1}{4\left(a+b\dfrac{\sin c}{c}\right)^2}\left\{\frac{4a^2}{u^2}\left(1-\frac{\sin 2u}{2u}\right)\right.$$

$$+\frac{b^2}{(u^2-c^2)^2}\left[(u^2+c^2)\left(2+\frac{\sin 2c}{2c}\right)+(u^2-c^2)\cos 2c-u\sin 2u-(u-c)^2\frac{\sin 2(u+c)}{2(u+c)}\right.$$

$$\left.-(u+c)^2\frac{\sin 2(u-c)}{2(u-c)}\right]-\frac{2ab}{u(u^2-c^2)}\left[\left(\frac{1-\cos 2u}{u}-\frac{2u}{u^2-c^2}\right)c\sin c-2u\left(\cos c+\frac{\sin c}{c}\right.\right.$$

$$\left.\left.\left.-\cos c\frac{\sin 2u}{2u}\right)+(u-c)\frac{\sin(2u+c)}{2(u+c)}+(u+c)\frac{\sin(2u-c)}{2(u-c)}\right]\right\} \qquad (43)$$

Substituting equations (40) and (43) into equation (16) we can obtain $g_e^*(\theta)$. In the normal direction

$$g_e^*(0)=1-\frac{T_e}{T_s}\left[\frac{1}{2}-\frac{\dfrac{2a^2}{3}+\dfrac{4ab}{c^2}\left(\dfrac{\sin c}{c}-\cos c\right)+\dfrac{b^2}{c^2}\left(1-\dfrac{\sin 2c}{2c}\right)}{4\left(a+b\dfrac{\sin c}{c}\right)^2}\right],\quad \frac{T_e}{T_s}\leqslant 1 \qquad (44)$$

When $u\to\infty$

$$g_e^*(\theta)\longrightarrow\left(\frac{a+b\cos c}{a+b\dfrac{\sin c}{c}}\right)^2\left\{\frac{\sin^2 u}{u^2}\right.$$

$$\left.-\frac{T_e}{T_s}\left[\frac{\sin^2 u}{u^2}-\frac{a^2+\dfrac{b^2}{4}\left(2+\cos 2c+\dfrac{\sin 2c}{2c}\right)+ab\left(\cos c+\dfrac{\sin c}{c}\right)}{(a+b\cos c)^2u^2}\right]\right\},\quad \frac{T_e}{T_s}\leqslant 1 \qquad (45)$$

Below is the specific result of calculation in an example where A=3.214. At this time

$$B^*(v)=1.4649+1.4421\cos 2.3037v,\quad |v|\leqslant 1 \qquad (46)$$

The maximum relative error of this for equation (35) is 0.86 percent, and root-mean square relative error is 0.34 percent;

$$G_{\max}^*=0.8615\times 4\pi WL/\lambda^2 \qquad (47)$$

$$g_m^*(\theta)\begin{cases}=g^*(\theta), & u\leqslant\pi/2\\ \to 0.7790/u^2, & u\to\infty\end{cases} \qquad (48)$$

$$g_e^*(0)=1-0.2361T_e/T_s,\qquad T_e/T_s\leqslant 1 \qquad (49)$$

$$g_e^*(\theta)\to 0.0671\frac{\sin^2 u}{u^2}-\frac{T_e}{T_s}\left(0.0671\frac{\sin^2 u}{u^2}-\frac{0.6139}{u^2}\right),\quad u\to\infty\quad \frac{T_e}{T_s}\leqslant 1 \qquad (50)$$

For the graph of $g_p^*(\theta,t)$ see Figure 5; Figure 6 is the graph of $g^*(\theta)$, where within plotting accuracy equation (36) is completely coincidental with it, so this graph also plots $g_m^*(\theta)$ and $g_e^*(\theta)$.

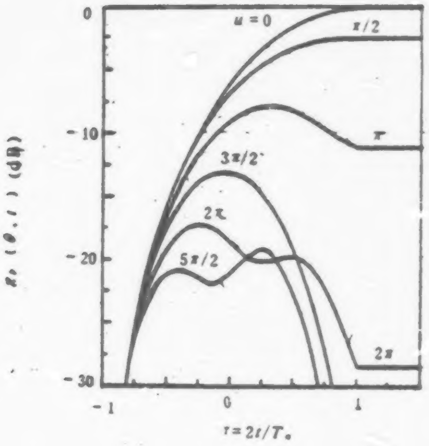

Figure 5. $g_p^*(\theta,t)$ for $I_0(3.214\sqrt{1-\nu^2})$ excitation

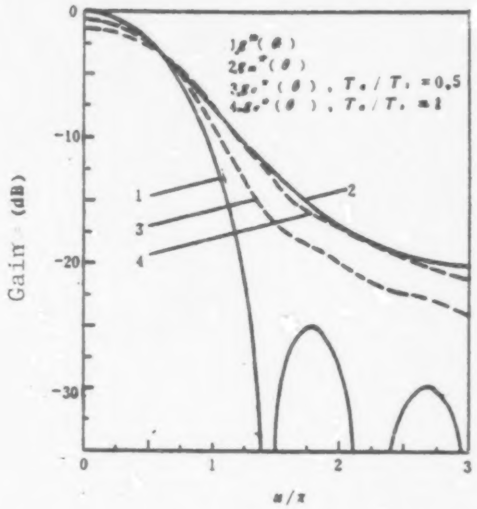

Figure 6. $g^*(\theta)$, $g_m^*(\theta)$ and $g_e^*(\theta)$ for $I_0(3.214\sqrt{1-\nu^2})$ excitation

III. The Effects on Angular Resolution

It can be seen from the preceding that the transient effects of end-fed array antennas cause a decline in the maximum value of pulse energy gain, that they cause an increase in the half-power width of pulse energy directivity graphs, that they cause the main and sidelobes of pulse energy directivity graphs to form one surface, and that they can also cause a rise in "sidelobe" levels. Consequently, as far as pulse energy sensitive radar is concerned, antenna transient effects will cause a decrease in the maximum functional distance, a worsening of angular resolution, and will also introduce a great amount of clutter. In order to quantitatively calculate the angular resolution of an antenna, Figures 7 and 8 give rating curves for half-power width Δu [the width when $g_e(\theta)$ descends to $g_e(0)/2$] and expansion coefficient $\Delta/\Delta u_0(T_a/T_s=0)$ and T_a/T_s antenna pulse energy directivity graph. It is worth noting that under conditions of constant excitation, only when $T_a/T_s=2/9$ is the first minimum point 3 dB lower than the first lobe of $g_e(\theta)$, that is, only at this time can the pulse energy directivity graphs begin to be similar to the steady-state directivity graph; under conditions of cosine excitation, the value of T_a/T_s is $32/675 \approx 1/20$; under conditions of $I_0(3.214\sqrt{1-\nu^2})$ excitation, this T_a/T_s value eventually reaches 1/30.

It can also be seen from the preceding that in the transient process end-fed array antennas produce transient pulses, the order of magnitude of the width being T_a, and the maximum amplitude value can be much greater than the steady-state value. Although the half-power width of the maximum instantaneous power directivity graph is equal to or approximates the steady-state power directivity graph, there is in the former absolutely no distinction between main and sidelobes. Moreover, when u is great, there is inverse decay with u^2. Consequently, as for radars sensitive to narrow pulse amplitude, antenna transient effects will introduce serious transient echo phenomena. Figure 9 is an image photographed in the field of a certain radar using long end-fed slot antenna, where in both directions beginning from bow and stern of a medium-size ship 1.7 nautical miles away there is approximately 20° of isolated clutter, caused by this kind of transient echo.

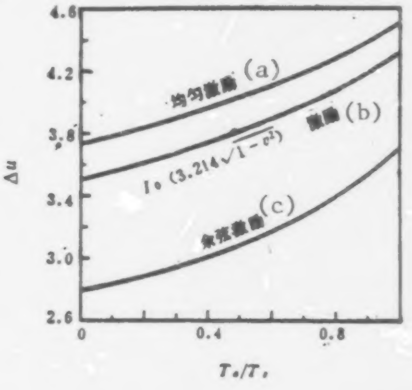

Figure 7. End-fed array antenna half-power width

Key:

a. Constant excitation
b. $I_0(3.124\sqrt{1-v^2})$ excitation
c. Cosine excitation

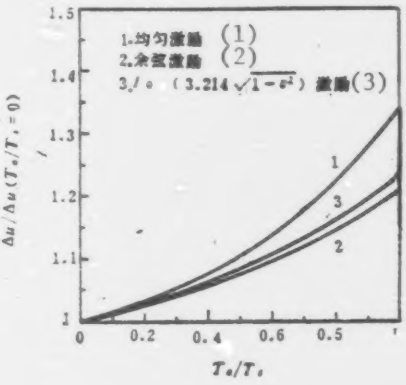

Figure 8. End-fed array antenna expansion coefficient

Key:

1. Constant excitation
2. Cosine excitation
3. $I_0(3.124\sqrt{1-v^2})$

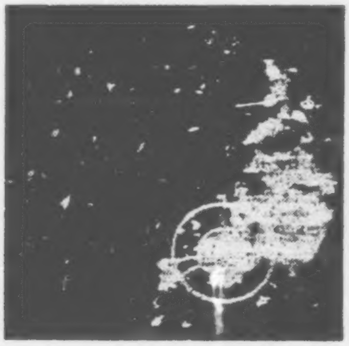

Figure 9. The phenomenon of isolated clutter caused by antenna transient effects, where ∇ is normal echo and between the ↑↑ is isolated clutter

An explanation of the isolated clutter phenomenon of Figure 9: When a large or medium size vessel is positioned within several nautical miles in a transverse direction, it will always produce the phenomenon of isolated clutter. Calculations prove that this phenomenon is not caused by antenna steady-state sidelobes, but rather by antenna transient echo.

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LARGE SIGNAL THEORY, COMPUTATION OF COUPLED-CAVITY TWT'S

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[Text] English Abstract: The physical model and numerical method for CCTWT's large-signal interaction are given. In this model, the electrical field distribution in the gap (both modulus and phase angle) as well as the backward wave influence and the relativistic effect are considered. And the mechanism of the electron beamwave interaction is discussed in great detail. Since the model uses the energy conservation law as a rule for the interaction, the computational results conform with the law accurately. The computation for an X-band CCTWT shows good agreement with the experiment values.

I. Introduction

When discussing interaction, the coupled-cavity TWT theory put forth by Pierce[1] considers only the synchronous space harmonics of electron beams and ignores its other space harmonics, thus there is a very great discrepancy with reality. Initially, Kino[2] put forth an interactive model of a lumped parameter triple-port [sanduankou [0005 4551 0656]] network which was completely different from Pierce's model,[1] but later some scholars carried out some explorations of triple port network interaction,[3,4] but it was impossible to find triple-port parameters that accurately reflected the interaction process of electron beams and waves. This is because the triple-port network which Kino used was theoretically only suited to linear problems of lumped parameters. Thus, people accepted the triple-port physical model but rejected the specific form of the triple-port network: i.e., two ports were used to represent the input and output coupling hole of a cavity, and a third port represented the interaction of the electron beam and the wave. The relationship between the "waves" of these three ports is not determined by the network parameters of Kino's triple port network, but by a series of equations that describe transmission, wave control of the electron beam, and the electron beam's excitation of the wave. In the same period of work, Vaughan[5] and ourselves[6] adopted the above described method. The inadequacy of Vaughan's model is in viewing the port in which the electron beam excites the electromagnetic waves as a "lumped" port, when the electron beam which has been or-

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ganized by the charge plate in one cycle goes through a cavity, it only excites the field in a "lumped" fashion in the center of the gap; but reference [6] takes distributed excitation into account, i.e., the cavity gap is not viewed as a lumped port, but as a distributed one. However, reference [6] has not yet completed program debugging and computational work. Connolly's[7] work is now the best coupled-cavity TWT large-signal theory. The work in this paper was carried out on the foundation of references [6] and [7].

II. Basic Physical Model

The basic physical model of interaction is illustrated in Figure 1. The voltage $\dot{V}$ (including forward wave and backward wave) in the illustration has a dual significance: on the one hand it represents the voltage at the gap, and through the Kosmahl[8] model, the electrical field distribution in the entire drift tube can be found using this voltage; on the other hand it is also a representation of power flow, similar to the wave parameters in a scatter matrix. The relationship of $\dot{V}$ and power flow P is defined as:

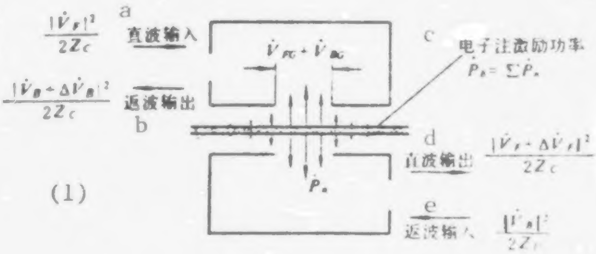
$$P = |\dot{V}|^2/2Z_c \qquad (1)$$

in which, Z_c is the overall interaction impedence. Figure 1 also illustrates the electron beam and wave interaction situation: when there is no electron beam, $\Delta\dot{V} = 0$. Regardless of whether it is a forward wave or a backward wave, input and output are equivalent (overlooking loss), and the gap voltage $\dot{V}_G$ at this time is also equal to $\dot{V}$. Z_c is generally computed through cold measurement [lengce [0397 3261]][9]. In this way the relationship between the electrical field and the power flow can be established through an intermediate variable $\dot{V}$.

Figure 1. Power flow relationship inside a cavity

Key:

a. forward wave input
b. backward wave output
c. electron beam excitation power
d. forward wave output
e. backward wave input


$\frac{|\dot{V}_F|^2}{2Z_c}$
a
直波输入
$\dot{V}_{FG} + \dot{V}_{BG}$
c
电子注激励功率
$\dot{P}_b = \sum \dot{P}_n$
$\frac{|\dot{V}_B + \Delta\dot{V}_B|^2}{2Z_c}$
返波输出
b
d
直波输出
$\frac{|\dot{V}_F + \Delta\dot{V}_F|^2}{2Z_c}$
(1)
$\dot{P}_n$
e
返波输入
$\frac{|\dot{V}_B|^2}{2Z_c}$

1. Representation of High Frequency Field

According to the complex voltage $\dot{V}_k$ (including forward wave voltage $\dot{V}_{Fk}$ and backward wave voltage $\dot{V}_{Bk}$) of the kth cavity provided by Kosmahl's model, the average electrical field on an electrically charged plate of radius b_k, and thickness l_d can be represented as:

$$\dot{E}_{rf.k}=\frac{\mu}{L_k l_k \sinh(\mu)}\sum_{m=-\infty}^{\infty}\frac{C_{mk}(\mu,\beta_{mk})I_1(\gamma_m b_k)}{\gamma_{mk}b_k I_0(\gamma_{mk}a_k)}\cdot\frac{\sin(\beta_{mk}l_d/2)}{(\beta_{mk}l_d/2)} \cdot \mathrm{Re}\{[\dot{V}_{Fk}\exp(-i\beta_{mk}z)+\dot{V}_{Bk}\exp(i\beta_{mk}z)]\cdot \exp i\omega t\} \tag{2}$$

in which $C_{mk}(\mu,\beta_{mk})=\dfrac{2l_k[\mu\sinh(\mu)\cos(\beta_{mk}l_k)+\beta_{mk}l_k\cosh(\mu)\sin(\beta_{mk}l_k)]}{\mu^2+(\beta_{mk}l_k)^2}$

$$\beta_{mk}=\beta_{0k}+(2m\pi/L_k), \qquad \gamma_{mk}=\sqrt{\beta_{mk}^2-(\omega^2/c^2)}$$

$\beta_0 L_k$ represents the shift oı each cavity; M is the field coefficient; L_k is the cycle; $2l_k$ is the gap width; a_k is the drift tube radius ·Mc is the velocity of light, let

$$\dot{E}_{rf.k}=\mathrm{Re}[(\dot{Q}_{nk}\dot{V}_{Fk}+\dot{Q}_{nk}^{*}\dot{V}_{Bk})\exp i\omega t_i(z_k)] \tag{3}$$

and comparing to Eq. (2) we get

$$\dot{Q}_{nk}=\sum_{m=-\infty}^{\infty}\frac{\mu}{L_k l_k\sinh(\mu)}\cdot\frac{C_{mk}I_1(\gamma_{mk}b_k)}{\gamma_{mk}b_k I_0(\gamma_{mk}a_k)}\left(\frac{\sin(\beta_{mk}l_d/2)}{(\beta_{mk}l_d/2)}\right)\cdot\exp(-i\beta_{mk}y_{nk}) \tag{4}$$

in which y_{nk} is the local coordinates of the kth cavity with the center of the gap as the point of origin, the subscript k indicates that our model permits cavities and electron beam raddi to be changeable. For the majority of intermediate cavities, when μ = 0.7, the $\dot{Q}_{nk}$ modulus and phase angle are as illustrated in Figure 2. This is the result computed when m takes ± 10 harmonic waves. The error at this time was less than 10^{-6}.

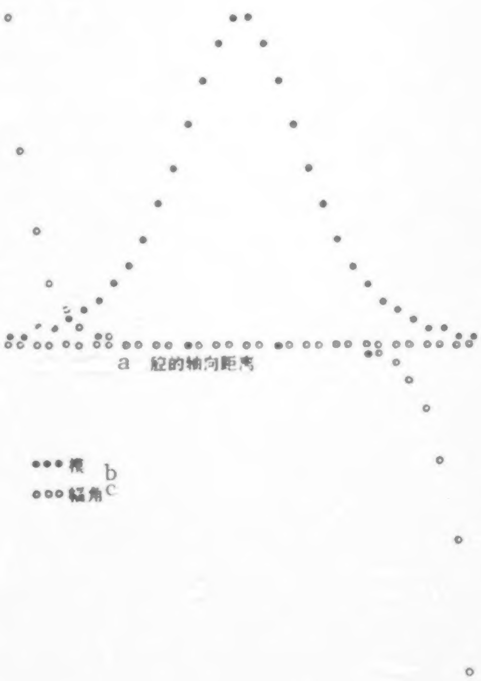


Figure 2. Modulus and phase angle of field shape function $\dot{Q}_{nk}$

Key:

a. axial distance of cavity
b. modulus
c. phase angle

2. Space Electron Field

Finding the space charge in problems in which distance is an independent variable was solved in physics and mathematics long ago. We adopted Green's function for high electron beam models.

For $|z|>l_d$: $$E_{sc}=\frac{4a^2q_d\,\mathrm{sgn}(z)}{(l_d')^2b^2\pi\varepsilon_0}\sum_{m=1}^{\infty}\frac{[J_1(\lambda_m b/a)]^2}{\lambda_m^4[J_1(\lambda_m)]^2}\left[\cosh\left(\frac{\lambda_m l_d'}{a}\right)-1\right]\cdot\exp\left(-\frac{\lambda_m|z'|}{a}\right) \tag{5}$$

For $|z|<l_d$: $$E_{sc}=\frac{4a^2q_d\,\mathrm{sgn}(z)}{(l_d')^2b^2\pi\varepsilon_0}\sum_{m=1}^{\infty}\frac{[J_1(\lambda_m b/a)]^2}{\lambda_m^4[J_1(\lambda_m)]^2}\left[1-\exp\left(-\frac{\lambda_m|z'|}{a}\right)-\exp\left(-\frac{\lambda_m l_d'}{a}\right)\cdot\sinh\left(\lambda_m\frac{|z'|}{a}\right)\right] \tag{6}$$

in which λ_m is the mth root of zero exponent Bessel function. q_d is the charge of the charged plate, l_d' and z' are the distance after relativistic theory correction and the thickness of the charged plate:

$$l_d'=l_d/\sqrt{1-(u_0/c)^2},\qquad z'=z/\sqrt{1-(u_0/c)^2} \tag{7}$$

U_0 is the electron forward flow velocity. For purposes of simplification, the subscript k has been left out of the above equations. To accelerate computing speed while maintaining precise conditions, we adopted the following: 1) first we set up a space charge table, then used the table in place of computing dot by dot. The grids on the table were not equidistant, and as the distances grew nearer the grids became denser; the number of terms accepted for high order harmonics at different distances were also not the same, maintaining precision at 10^{-6}. 2) We did not compute the space charge at every step, but once at every N steps, the point derived from computations was treated as a sample point of the space charge, the values of the space charges at other points was found by secondary extrapolation from these sample points; in every cavity, the precision of the interpolated points was checked and if the error exceeded the set value, N was automatically reduced by half.

3. Equation of Motion

Assuming that the force exerted within the region Δz in the charge plate does not change, we used the equation of uniformly accelerated motion and not the usual uniform velocity equation. Similarly, we dropped out the subscript k representing the number of cavities. Considering post-revision relativistic theory, the acceleration is:

$$a_n=-(E_{sc.n}+E_{rf.n})\cdot\eta\cdot[1-(v_n^2/c^2)]^{3/2} \tag{8}$$

$$v_{n+1}=v_n+a_n\Delta t \tag{9}$$

$$\Delta t=\Delta z/[(v_{n+1}+v_n)/2] \tag{10}$$

and combining Eqs. (9) and (10) and using $\varphi_{n+1}-\varphi_n$ to represent Δt, we get:

$$v_{n+1}=\sqrt{v_n^2+2a_n\Delta z} \tag{11}$$

$$\varphi_{n+1}=\varphi_n+2\omega\Delta z/(v_{n+1}+v_n) \tag{12}$$

in which v_n, φ_n, v_{n+1} and φ_{n+1} represent respectively the initial and final speed and position of the nth step of the charge plate. n represents the discretization of z direction, the ultimate value of n is also the initial value of n + 1. Similar consideration is given to the relationship of kinetic power and the voltage as well as velocity of the charge plate after the relativistic effect, it was:

$$u_0=c\sqrt{1-\frac{1}{1+(qV_0/m_0c^2)^2}} \tag{13}$$

$$P=m_0c^2\left[\frac{1}{\sqrt{1-(v^2/c^2)}}-1\right] \tag{14}$$

4. Electron Beam's Excitation of the Field

The electron beam's excitation of the field is the most difficult problem in large signal interaction theory. We first considered the forms which interaction should take from the perspective of the general laws of the conservation of energy. The relationship of the power flow is still as illustrated in Figure 1. Below we first compute the work done by the jth charge plate in the process of n step motion:

$$\Delta u_{j,n,k}=q_d\cdot E_{j,n,k}\cdot\Delta z \tag{15}$$

$$q_d=I_0/F\cdot N_d \tag{16}$$

in which, I_0 is the forward current, F is the frequency, N_d is the number of charge plates sampled in each cycle. When discussing excitation we did not consider space charge field. In the Δz region, E_{rf} is a constant for each charge plate. This coincides with the assumptions in the equation of motion. Substituting in Eq. (3) and Eq. (16) we get:

$$\Delta u_{j,n,k}=\frac{I_0}{FN_d}\mathrm{Re}[(\dot{Q}_{nk}\cdot\dot{V}_{FGk}+\dot{Q}^*_{nk}V_{BGk})\cdot\exp i\omega t_j(z_{nk})]\Delta z \tag{17}$$

Integrating all the charge plates within one cycle and dividing it by the cycle we obtained the power P_{nk} of excitation in the process of the nth step of motion in the cavity, and then integrating in the entire cavity length, we obtained the power which the electron beam excited in the entire kth cavity. Distributed excitation is the primary difference between this mode and Vaughan's model. Because at each step distributed excitation has its own phase, we did not have to make any assumptions regarding the excitation phase.

$$P_{bk}=\frac{I_0}{2\pi}\int_{-L/2}^{L/2}\mathrm{Re}\Big\{(\dot{Q}_{nk}\dot{V}_{FGk}+\dot{Q}^*_{nk}\dot{V}_{BGk})\cdot\Big[\int_0^{2\pi}\exp i\varphi(\varphi_0,\ z)d\varphi_0\Big]\Big\}dz \tag{18}$$

From Figure 1 it is easy to compute the difference of the electrical field energy of the flow in and out of k cavity, and through the complex number operation we get:

$$\begin{aligned}P_{ck}&=\frac{1}{2Z_c}[(\dot{V}_{Fk}+\Delta\dot{V}_{Fk})^2-\dot{V}^2_{Fk}+(\dot{V}_{Bk}+\Delta\dot{V}_{Bk})^2-\dot{V}^2_{Bk}]\\&=\frac{1}{Z_c}\mathrm{Re}\Big[\Big(\dot{V}_{Fk}+\frac{\Delta\dot{V}_{Fk}}{2}\Big)\Delta\dot{V}^*_F+\Big(\dot{V}_{Bk}+\frac{\Delta\dot{V}_{Bk}}{2}\Big)\Delta\dot{V}_{Bk}\Big]\end{aligned} \tag{19}$$

The conservation of energy demands that $p_c = p_b$, and since the forward wave and the backward wave are orthogonal, they should be equivalent, and the forward wave can be obtained:

$$\begin{aligned}&\frac{1}{Z_c}\mathrm{Re}\Big[\Big(\dot{V}_{Fk}+\frac{\Delta\dot{V}_{Fk}}{2}\Big)\cdot\Delta\dot{V}^*_{Fk}\\&\quad=\frac{I_0}{2\pi}\mathrm{Re}\Big\{\dot{V}_{FGk}\int_{-L/2}^{L/2}\dot{Q}_{nk}\cdot\int e^{i\varphi(\varphi_0 z)}d\varphi_0 dz\Big\}\end{aligned} \tag{20}$$

Eq. (20) is the criterion which interaction must observe when satisfying the relationship of conservation of energy. Just like the overwhelming majority of interaction phenomena, the conservation of energy is only a necessary condition and not a sufficient condition. Only under the simplest forms of motion can the conservation of energy criteria completely determine the form of interaction, but in most circumstances, just the conservation of energy alone is not sufficient to determine completely the form of interaction but must be aided by other restrictions, or other criteria, before it can completely determine the form of interaction. Interaction in a coupled-cavity TWT is one of these more complex forms. We must provide other criteria to determine the relationship of gap voltage $\dot{V}_{FG}$, pre-excitation input voltage $\dot{V}_{Fk}$, and the voltage increase produced by excitation $\Delta\dot{V}_{Fk}$. To determine precisely the relationship between $\dot{V}_{FG}$ and $\dot{V}_{Fk}$ and $\Delta\dot{V}_{Fk}$ in an excitation field, it is necessary to find the form of the excitation field and this is an extremely complex problem. We can only use approximate methods, and at first approximation, the gap voltage can be viewed as the average value of entry and exit voltages, i.e.,

$$\dot{V}_{FGk}=\dot{V}_{Fk}+\frac{1}{2}\Delta\dot{V}_{Fk} \tag{21}$$

and substituting Eq. (21) in Eq. (20), we get:

$$\Delta\dot{V}_{Fk}=\int_{-L/2}^{L/2}\dot{Q}^*_{nk}\Big(\frac{I_0Z_c}{2\pi}\int_0^{2\pi}e^{i\varphi(\varphi_0,z)}d\varphi_0\Big)dz \tag{22}$$

Similarly, for the backward wave we get:

$$\Delta\dot{V}_{Bk}=\int_{-L/2}^{L/2}\dot{Q}_{mk}\left(\frac{I_0Z_c}{2\pi}\int_0^{2\pi}e^{-i\varphi(\varphi_0,z)}d\varphi_0\right)dz \tag{23}$$

III. Outline of the Program

Since people are already familiar with large signal computations of ordinary helix TWT or klystrons, there is nothing special about writing a program for space charge, equation of electron motion, and wave excitation. The primary problem in program design was the problem of identifying forward wave and backward wave transmission, superposition, iteration, and convergence. The equations for forward and backward wave transmission are as follows:

$$\dot{V}_{Fk}=\dot{V}_{F(k-1)}\cdot\exp(-i\beta_0L_{k-1})\cdot\exp(-\alpha_{k-1}) \tag{24}$$

$$\dot{V}_{Bk}=\dot{V}_{B(k+1)}\cdot\exp(-i\beta_0L_{k+1})\cdot\exp(-\alpha_{k+1}) \tag{25}$$

Each cycle is divided into N_d charge plates ($N_d = 24$), and each cavity is divided into 32 grids. Each step requires first computing the space charge and high frequency field, then computing the motion of the charge plate; through superposition of the charge plate phases of one cycle, a "convection current" was obtained, the "convection current" and the field shape coefficient were multiplied to obtain the contribution of each step towards the "excitation voltage"; after travelling one cavity, the contributions of each step were superposed, i.e., the "excitation voltages" $\dot{V}_F$ and $\dot{V}_B$ for the entire cavity were calculated. For this article a subroutine DVCV is used to represent this process.

Cavity Iteration: Because the $\Delta\dot{V}_F$ and $\Delta\dot{V}_B$ obtained through the DVCV process and the gap voltages $\dot{V}_{FG}$ and $\dot{V}_{BG}$ are related, and $\dot{V}_{FG}$ also in turn are related to $\Delta\dot{V}_F$ and $\Delta\dot{V}_B$, this requires an iteration. In cavity iteration, we change only $\dot{V}_{FG}$ and store $\Delta\dot{V}_B$, therefore, cavity iteration is also a problem of forward wave convergence. Computations show that forward wave convergence is not difficult, and generally with three iterations, the relative error of the phase and amplitude of $\Delta\dot{V}_F$ is less than 1 percent.

Backward Wave Superposition and Segment Iteration: According to the above process, computing from the first cavity to the last cavity of a segment, one obtains a $\{\Delta\dot{V}_{BK}\}$ number group. Then according to the equation

$$\dot{V}_{Bk}=\dot{V}_{B(k+1)}\cdot\exp(-i\beta_0L_{k+1})\cdot\exp(-\alpha_{k+1})+\Delta\dot{V}_{Bk} \tag{26}$$

and letting input of the last cavity $\dot{V}_{B(k+1)}$ equal zero, one can compute from the last cavity back to the first cavity and obtain another number group $\{\dot{V}_{Bk}\}$. However, $\dot{V}_{Bk}$ is not used in backward voltage of the gap of an electron beam. (25)

$$\dot{V}_{BGk}=\dot{V}_{Bk}-\frac{1}{2}\Delta\dot{V}_{Bk} \tag{27}$$

Adding the new $\dot{V}_{BGk}$ and $\dot{V}_{FGk}$ together and computing from the first cavity towards the last, is segment iteration. Segment iteration solves the problem of backward wave convergence. The best criterion of backward wave convergence is the value of the first cavity's backward wave, this is because it is the superposition of the backward waves of all the cavities. But in actual computations, the output voltage of the last cavity is also used as a criterion. We used the first cavity's backward wave value as the convergence criterion for the input segment, to ensure higher precision and the output power was the criterion of convergence for the output segment, to save on computer time.

Rectifier Iteration: Rectifier iteration is to select appropriate input power to ensure the circuit's output cavity work is near the saturation point. Because rectifier iteration is the loop at the most external layer, it uses a great deal of computer time and is not suited to multiple iterations. Actually, it is only for suitable adjustment of the input power to guarantee that the difference between the gain of the last cavity and the maximum gain in the other cavities is less than 1 dB; under normal circumstances, one adjustment of the input power is sufficient.

IV. Computation Results and Discussion

The computational results of the overall program obtained are in two parts: one is used to check the rationality of the program in terms of physics, such as the influence of gap electron field distribution (including phase distribution) on interaction, the influence of backward waves, especially to carry out careful checking of the conservation of energy; the second part is the computation of an actual rectifier.

To check the degree of conservation of power, we defined the conservation of power coefficient α:

$$\alpha = \frac{P_{Fk} - P_0 - P_{B(k+1)} + P_{B1} + P_{beam} + P_{loss}}{V_0 I_0} \qquad (28)$$

in which P_{Fk} and P_0 are the forward wave input power and the output power to k cavity; $P_{B(k+1)}$ and P_{B1} are backward wave power input to k cavity and backward wave power output from the first cavity. If k is the last cavity, $P_{B(k+1)} = 0$. P_{beam} is the kinetic energy power of the electron beam; P_{loss} is the over all loss of k cavity. If space charge is not considered in computations, within the molecules are arrayed the forward current input power of all the power and should be equivalent to the electron beam. Therefore $\alpha=1$ represents the energy's precise conservation. When space charge is considered, the space charge potential energy power should be added to the molecule to obtain conservation of energy. However, computing space charge potential power is both time-consuming and without any practical significance. Therefore, first of all Table 1 gives the results when we do not have to consider the space charge in computing. From the table we can see that before counting in backward waves, the precision of the first 10 cavities a is as high as 10^{-6}. But when the backward wave is counted in, a=0.999996 for the tenth cavity. This error is determined by the convergence precision of backward wave iteration. This precision is high enough.

Table 2 gives the computational results of the actual circuit, and from here it can be seen that after considering the space charge the relationship of the conservation of energy is still satisfactory enough. Except for the last five cavities, a is greater than 0.99, i.e., the space charge potenital energy power accounts for less than 1 percent of the total power. By the last several cavities, the bunching of the electron beams is very tight, the space charge potential energy power is increased, but it also accounts for only 1-2 percent of the total power. (30)

From the computational results above it can be seen that the model used in this paper is very rational, and computational precision is high enough. Figure 3 is a comparison of the theoretical computations and actual test results of a coupled-cavity TWT. The computation of this circuit's impedence

Table 1. Computational results when space charge not considered (input = 10W)

k	$\lvert V_{Fk}\rvert$	G_k	P_{Fk}	P_{beam}	P_{Bk}	P_{B1}	P_{Floss}	P_{Bloss}	a

(a) NB = 1 Results when backward wave not considered

1	$0.108D+3$	$-0.880D-1$	$0.980D+1$	$0.783D+5$	0.0	0.0	0.0	0.0	$0.100000D+1$
2	$0.101D+3$	$-0.715D+0$	$0.848D+1$	$0.783D+5$	0.0	0.0	$0.843D+0$	0.0	$0.100000D+1$
3	$0.944D+2$	$-0.129D+1$	$0.743D+1$	$0.783D+5$	0.0	0.0	$0.157D+1$	0.0	$0.100000D+1$
4	$0.938D+2$	$-0.134D+1$	$0.734D+1$	$0.783D+5$	0.0	0.0	$0.221D+1$	0.0	$0.100000D+1$
5	$0.105D+3$	$-0.343D+0$	$0.924D+1$	$0.783D+5$	0.0	0.0	$0.284D+1$	0.0	$0.100000D+1$
6	$0.132D+3$	$0.163D+1$	$0.145D+2$	$0.783D+5$	0.0	0.0	$0.364D+1$	0.0	$0.100000D+1$
7	$0.173D+3$	$0.399D+1$	$0.251D+2$	$0.782D+5$	0.0	0.0	$0.489D+1$	0.0	$0.100000D+1$
8	$0.227D+3$	$0.633D+1$	$0.430D+2$	$0.782D+5$	0.0	0.0	$0.705D+1$	0.0	$0.100000D+1$
9	$0.292D+3$	$0.851D+1$	$0.710D+2$	$0.782D+5$	0.0	0.0	$0.107D+2$	0.0	$0.100000D+1$
10	$0.367D+3$	$0.105D+2$	$0.112D+3$	$0.781D+5$	0.0	0.0	$0.169D+2$	0.0	$0.100000D+1$

(b) NB = 5 Results at five iterations (backward wave already converged)

1	$0.108D+3$	$-0.879D-1$	$0.980D+1$	$0.783D+5$	$0.101D+0$	$0.992D-1$	0.0	$0.871D-2$	$0.100000D+1$
2	$0.101D+3$	$-0.697D+0$	$0.852D+1$	$0.783D+5$	$0.131D+0$	$0.992D-1$	$0.843D+0$	$0.200D-1$	$0.100000D+1$
3	$0.947D+2$	$-0.127D+1$	$0.747D+1$	$0.783D+5$	$0.218D+0$	$0.992D-1$	$0.158D+1$	$0.388D-1$	$0.100000D+1$
4	$0.942D+2$	$-0.131D+1$	$0.740D+1$	$0.783D+5$	$0.104D+0$	$0.992D-1$	$0.222D+1$	$0.479D-1$	$0.999999D+0$
5	$0.106D+3$	$-0.325D+0$	$0.926D+1$	$0.783D+5$	$0.519D+0$	$0.992D-1$	$0.286D+1$	$0.924D-1$	$0.999999D+0$
6	$0.132D+3$	$0.163D+1$	$0.145D+2$	$0.783D+5$	$0.474D-1$	$0.992D-1$	$0.365D+1$	$0.965D-1$	$0.999999D+0$
7	$0.173D+3$	$0.397D+1$	$0.250D+2$	$0.782D+5$	$0.104D+1$	$0.992D-1$	$0.491D+1$	$0.186D+0$	$0.999998D+0$
8	$0.226D+3$	$0.631D+1$	$0.427D+2$	$0.782D+5$	$0.876D-2$	$0.992D-1$	$0.705D+1$	$0.188D+0$	$0.999998D+0$
9	$0.291D+3$	$0.848D+1$	$0.704D+2$	$0.782D+5$	$0.177D+1$	$0.992D-1$	$0.107D+2$	$0.336D+0$	$0.999996D+0$
10	$0.366D+3$	$0.105D+2$	$0.111D+3$	$0.781D+5$	0.0	$0.992D-1$	$0.168D+2$	$0.336D+0$	$0.999996D+0$

Table 2. Actual computation results of coupled-cavity TWT

(a) First segment (before attenuator)

k	$\|V_{Fk}\|$	η	G_k	P_{Fk}	P_{beam}	P_{Bk}	P_{B1}	P_{loss}	α
1	0.556D+2	0.141D−4	−0.156D+0	0.110D+1	0.764D+5	0.155D+1	0.148D+1	0.352D−1	0.100D+1
2	0.451D+2	0.923D−5	−0.199D+1	0.723D+0	0.764D+5	0.211D+1	0.148D+1	0.108D+0	0.100D+1
3	0.466D+2	0.988D−5	−0.169D+1	0.773D+0	0.764D+5	0.299D+1	0.148D+1	0.193D+0	0.100D+1
4	0.803D+2	0.293D−4	0.303D+1	0.229D+1	0.764D+5	0.150D+1	0.148D+1	0.245D+0	0.100D+1
5	0.118D+3	0.632D−4	0.637D+1	0.495D+1	0.764D+5	0.153D+1	0.148D+1	0.555D+0	0.100D+1
6	0.153D+3	0.106D−3	0.860D+1	0.828D+1	0.763D+5	0.434D+1	0.148D+1	0.212D+1	0.100D+1
7	0.185D+3	0.156D−3	0.103D+2	0.112D+2	0.763D+5	0.179D+1	0.148D+1	0.381D+1	0.100D+1
8	0.218D+3	0.215D−3	0.117D+2	0.169D+2	0.763D+5	0.533D+1	0.148D+1	0.599D+1	0.100D+1
9	0.306D+3	0.427D−3	0.147D+2	0.334D+2	0.763D+5	0.799D+1	0.148D+1	0.656D+1	0.100D+1
10	0.435D+3	0.860D−3	0.177D+2	0.673D+2	0.763D+5	0.0	0.148D+1	0.732D+1	0.100D+1

(b) Second segment (after attenuator, output segment)

11	0.258D+3	0.304D−3	0.132D+2	0.238D+2	0.762D+5	0.493D+2	0.148D+1	0.773D+2	0.999D+0
12	0.488D+3	0.108D−2	0.187D+2	0.846D+2	0.761D+5	0.115D+2	0.148D+1	0.797D+2	0.999D+0
13	0.649D+3	0.192D−2	0.212D+2	0.150D+3	0.761D+5	0.670D+2	0.148D+1	0.105D+3	0.999D+0
14	0.833D+3	0.316D−2	0.234D+2	0.247D+3	0.759D+5	0.354D+2	0.148D+1	0.136D+3	0.999D+0
15	0.106D+4	0.514D−2	0.255D+2	0.402D+3	0.757D+5	0.557D+2	0.148D+1	0.187D+3	0.998D+0
16	0.147D+4	0.977D−2	0.283D+2	0.764D+3	0.753D+5	0.232D+3	0.148D+1	0.294D+3	0.998D+0
17	0.201D+4	0.184D−1	0.310D+2	0.144D+4	0.742D+5	0.349D+2	0.148D+1	0.428D+3	0.996D+0
18	0.257D+4	0.302D−1	0.332D+2	0.236D+4	0.731D+5	0.209D+3	0.148D+1	0.706D+3	0.995D+0
19	0.320D+4	0.467D−1	0.351D+2	0.365D+4	0.713D+5	0.336D+3	0.148D+1	0.111D+4	0.992D+0
20	0.403D+4	0.740D−1	0.371D+2	0.579D+4	0.686D+5	0.153D+2	0.148D+1	0.119D+4	0.990D+0
21	0.447D+4	0.104D+0	0.385D+2	0.811D+4	0.665D+5	0.549D+3	0.148D+1	0.134D+4	0.988D+0
22	0.551D+4	0.138D+0	0.398D+2	0.108D+5	0.631D+5	0.224D+3	0.148D+1	0.153D+4	0.986D+0
23	0.613D+4	0.171D+0	0.407D+2	0.134D+5	0.601D+5	0.151D+3	0.148D+1	0.178D+4	0.984D+0
24	0.639D+4	0.186D+0	0.410D+2	0.145D+5	0.590D+5	0.417D+3	0.148D+1	0.209D+4	0.986D+0
25	0.624D+4	0.177D+0	0.408D+2	0.139D+5	0.590D+5	0.0	0.148D+1	0.242D+4	0.986D+0

was done through a program from "large perturbation method" cold measure results. The impedence computation method is discussed in another paper.[9] The distributed decay of this circuit and the decay of the cavities were both provided through cold measure. Figure 3 also provides the computational results while both considering backward waves and not considering backward waves. From this we can see that the further β_0L gets from 1.5Π, the greater the impact of the backward wave. The computational results and the test results basically agree, but the program has to perform more computations so that it is constantly improved. When we consider backward waves now, the computational frequency criteria are β_0L from 1.333Π to 1.6Π. When $\beta_0L>1.6Π$ the gain declines very quickly, therefore before carrying out computation

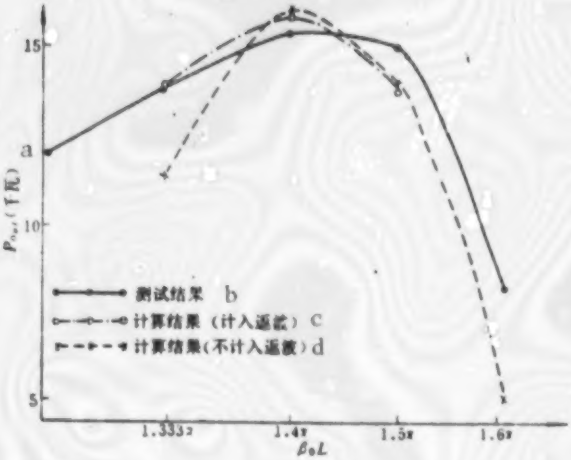


Figure 3. Comparison of computed results and measured results

Key:

a. kw
b. measured results
c. computed results (including backward wave)
d. computed results (not including backward wave)

again, when $\beta_0 L<1.333\Pi$, there were five iterations without convergence. Because the time required for each backward wave iteration is long, it does not permit continuous computation, but when by actual measurement $\beta L<1.333\Pi$, it is still highly effective and the circuit is stable. Thus, much work still needs to be done on how to expand computation frequency band when time permits, in the iterative process for example, how to both guarantee accuracy and reduce as much as possible the multiple computations of space charge and what kind of relaxation factors to select during backward wave iteration all need further study.

Comrades Song Peide [1345 1014 1795], Wu Jingxian [0702 7234 6343], and Sun Furu [1327 4395 1172] participated in this work, and Comrades Chen Xiulan [7115 4423 1526] and Feng Songyun [7458 2646 0061] contributed much valuable test data for the computations in this article and we would like to express our thanks.

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APPLIED SCIENCES

EXPERIMENTAL FACILITY OF SHANGHAI GAS TURBINE FACTORY DETAILED

Beijing ZHONGGUO JIXIE BAO in Chinese 6 Dec 85 p 1

[Article by Lu Bo [7120 3134]]

[Text] The completely Chinese-designed and built 200-ton high-speed dynamic balance experimental facility of the Shanghai Gas Turbine Factory was certified at the Ministry level on 23 November 1985. Experts agreed that this facility has reached a standard comparable to that of similar product built by the Schenck Co of West Germany. A few days ago, experts from Sweden, the United States, West Germany were invited to tour the facility and made the following remarks after the tour: "You have designed and built a world-class dynamic balance facility." "Your success will break Schenck Co's monopoly of the world market."

The 200-ton, high-speed dynamic balance experimental facility of the Shanghai Gas Turbine Factory is one of the nuclear power engineering projects; it is an essential experimental facility for developing nuclear power generators and large thermal power generators. Under the sponsorship of the Ministry of Machine Building and the Shanghai No 1 Electromechanical Bureau, the research and design of this facility began in 1975, and the construction work took 10 years to complete. Since its completion, the facility has been used for the dynamic balance tests of 10 gas turbine rotors. The results showed that all performance indices have reached the standards of similar products made abroad. One of the dynamic balance tests involved the gas turbine rotor of a 125,000-kW generator of the Minxin Power Plant; they were very satisfied with the result. The actual cost of the facility is about 10 million yuan, which is only one-third of the cost of a similar facility imported from abroad.

This experimental facility was designed by the No 2 Design Institute of the Ministry of Machine Building. Significant contributions were also made by the Shanghai Experimental Machine Factory, the Shanghai Gas Turbine Factory, the Shanghai Electric Motor Factory, the Shanghai Design Institute of Electromechanical Products, the Shanghai No 2 Electric Meter Factory, the Shanghai Jiaotong University and the Shanghai Research Institute of Power Tools. With cooperative efforts by all participants, solutions were found to many difficult problems such as the sealing of vacuum chambers, supplying oil to bearings under vacuum conditions, deformation and sealing of the 8.5-m diameter door of the vacuum chamber.

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CSO: 4008/39

FIRST FREE-ELECTRON LASER OPERATIONAL

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 12, No 12, 20 Dec 85 p 767

[Article by Zhu Cheng [5969 2052], Lu Zaitong [7120 6528 6639], Shi Ruigen [2457 3843 2704], Wang Zhijiang [3769 0037 3068], Shi Jinchuan [2457 3160 1556], and Hu Yu [5170 3558]: "First Free-Electron Laser in China Now Operational"]

[Text] Output from China's first free-electron laser has been obtained. This free-electron laser is based on stimulated Raman scattering.

The electron beam is emitted from a retrofitted model EB-1 high current pulsed electron accelerator. The voltage is 0.5 MeV, the beam current is 50 kA, and the pulse width is 60 ns. The 6 mm diameter solid cylindrical electron beam and the 16 mm diameter, 1 mm thick hollow cylindrical electron beam both produced laser output. The electron beam enters the drift tube under the guidance of a strong axial magnetic field (0-20 kG variable) and is pumped by the static magnetic wigglers. (Both the right-handed circularly polarized double-wound electromagnetic wiggler and the axially symmetric ring-shaped permanent magnetic wiggler had laser outputs.) Under the appropriate combination of parameters, coherent spontaneous amplication of laser radiation is obtained. The radiation originates from the Ka band at the end of the drift tube and the output comes out of a horn after a gain of 13 dB. The output is received by an H-surface horn and is guided into the shielded layer by a 3.3 m long waveguide. The waveform of the radiation is recorded by a system consisting of a high pass filter, a variable attenuator, a crystal detector, and an oscilloscope. Typical experimental results are: width at half maximum = 20 ns, average power = 0.5 MW, and the wavelength is in the Ka band (8 mm or so). The output level is still one to two orders of magnitude lower than the best results obtained abroad, but the level will be improved after parameter optimization experiments. Details of the experimental setup and analysis of the experimental results will be published separately.

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OPTICAL DISK MEDIA RESEARCH DISCUSSED

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 12, No 12, 20 Dec 85 pp 705-712

[Article by Hou Jinchun [0186 0603 2504] and Gan Fuxi [1626 4395 3588] of the Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences: "Research and Development of Optical Disk Media"]

[Text] Abstract: A review of the current status of the research and development on various optical disk media is presented. It is noted that research around the world on the media for nonerasable optical disk is almost over and nonerasable optical disk has been successfully used for CD, LD player and DRAW devices. On the other hand, great efforts are now being made to search the more suitable medium for erasable optical disks. Extensive experiments on various material systems including optical characteristic change, phase transition and magneto-optical recording media are under way. It is expected that fruitful results will appear in the next 2 or 3 years.

The new optical disk information storage technology has the advantages of high storage density (1-2 orders of magnitude greater than magnetic disk storage), rapid access, interfaceable to computer and other information system, long life (greater than 10 years) and low price per bit. The research of nonerasable optical disk material began in the mid-1960's, shortly after the debut of lasers. Today nonerasable optical disks are in the application stage and large-scale research and development of nonerasable optical disk material has gained maturity. Erasable optical disks have just been developed and the material research of erasable optical disks is being pursued actively.

The phase transformation, change of state and other property changes caused by the interaction of the laser and the material can all be used in information storage. As far as optical storage materials are concerned, the general requirements are: 1) high sensitivity to light, 2) high storage density, 3) high signal-to-noise ratio, 4) stable over long period of time, and 5) readily formed into large uniform thin films. The optical disk storage materials developed to date are mostly heat sensitive thin films that undergo phase transformation, change of state or other property changes upon absorbing the light energy. Nonerasable disks undergo nonreversible changes and erasable disks undergo reversible changes.

I. Burn-in Type Optical Disk Material

The burn-in type optical disks are one-time writing disks. The master disks of digital compact disks and videodisks currently sold on foreign markets belong to this type.

The material at the focal point absorbs laser energy and forms cavities or bubbles. The signals are recorded by these cavities or voids produced in the thermal burning process because the reflectivity of the cavities or bubbles is different from that of the surrounding medium. The general material requirements are: 1) The coefficient of absorption must be large for the wavelength used in the writing process; 2) the burning should take place at a low temperature; 3) it should be a large difference in reflectivity between the host medium and the cavities or bubbles; 4) the cavities or bubbles should be uniform and regular; and 5) the voids, bubbles and the medium should have long stability. Figure 1 shows the recording mechanisms of a single layer burn-in type optical disk. Figure 1(a) shows a simple burn-in type structure; Figure 1(b) shows the low reflectivity microscopic needle structure produced by plasma etching on thin films of silicon or germanium.[1] The bubble and blister structures in Figure 1(c) and 1(d) are produced in semiconductors containing hydrogen[2] and in organic emulsion.[3] Figure 1(e) shows the high reflectivity RhSi alloy recording mechanism[4] formed on a rhodium substrate by laser burning. To improve the burning action, the signal-to-noise ratio, and the stability, a number of multilayered structures have been used. The main feature is that the abscrption layer and the burn-in layer are separated and that an antireflection coating and a protective coating are used.

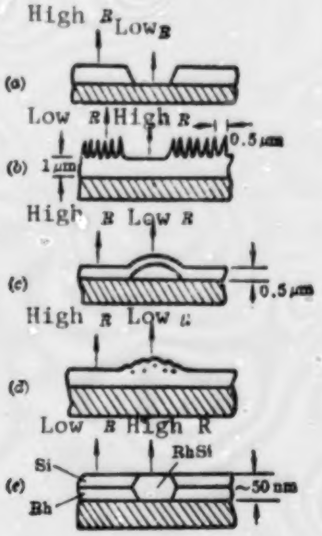

Figure 1. Single layered structures for burn-in recording

Figures 2(a) and 2(b) show the bubble formation in a two-layered and a three-layered structure. Figure 2(c) shows the most commonly used metal film sandwich structure containing a protective gas to prevent the oxidation of the metal film. More complex structures containing a reflection layer and a number of protective layers also exist (Figure 2(d)).

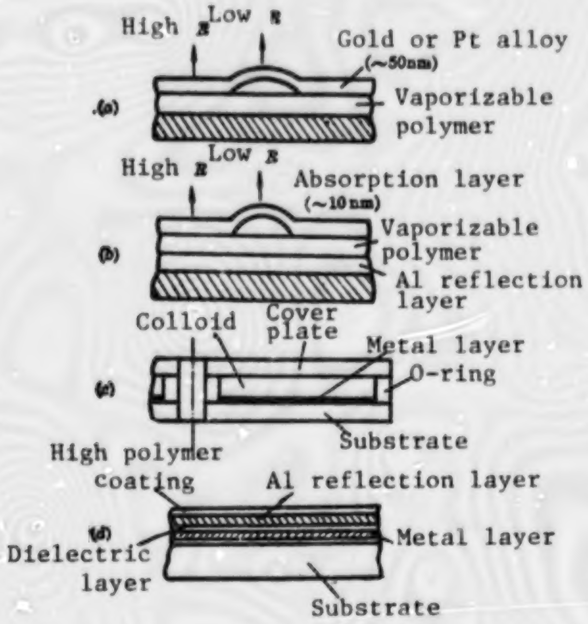
High R
Low R
Gold or Pt alloy
(~50nm)
Vaporizable polymer
(a)
High R
Low R
Absorption layer
(~10nm)
Vaporizable polymer
(b)
Al reflection layer
Colloid
Cover plate
Metal layer
O-ring
(c)
Substrate
High polymer coating
Al reflection layer
(d)
Metal layer
Dielectric layer
Substrate

Figure 2. Multi-layered structures for burn-in recording

There is a great variety of burn-in type optical disk materials. Metal and alloy film disks are most extensively researched and developed; more than 80 percent of the nonerasable disks sold on the foreign market are metal or alloy film disks. Table 1 shows the test results of metal disk materials.[5] Tellurium has a low melting point (450°C), a low heat conductivity (24 W/m·deg), a high absorbing ability for light, and good hole-forming properties. However, amorphous tellurium films cannot be easily formed and the grain boundaries in polycrystalline films affects the evenness of hole formation. Selenium and antimony are often added to tellurium in forming amorphous films. Common tellurium based films are Te-Bi, Te-C, and Te/Te-Se double films.[6-8] Sulphur series compounds have also been investigated, including As-Te, Ge-Te, As-Se, Ge-Se and Sb-S. $As_{20}Te_{80}$ has the best performance.[9] The threshold of the writing laser is low, the holes are even and free of debris. The amount of debris in the hole depends on the difference in the boiling points of the two elements.

The main problem with tellurium alloy films is their chemical instability. They can be easily oxidized or damaged by electric corrosion. This is a common problem with low melting point materials. The chemical stability of the films may be improved by changing the alloy composition and raising the melting point, but this often increases the laser power density required in the hole burning. Other approaches include applying protective coating, improving the outer coating to make it inpemable to gas, and designing new multilayer or sandwich structures. Today a 30 cm optical disk can store 10^{10}-10^{11} binary signals with a video signal-to-noise ratio greater than 60 dB, a normalized error rate of 10^{-12}, and a storage life longer than 10 years. Companies are still working on the research and development of material improvements and film manufacture technology to make them even better. Organic recording media should be given special attention. The Ricoh Company in Japan has recently explored the possibility of using organic sec-methyl dye to replace the metal film. This organic material has a low thermal conductivity and the spot size can be as small as 0.7 μm (the smallest spot size on a metal film is 0.9 μm). The storage capacity will be raised by 30 percent and the cost is only about one-third of that of metal film optical disks.[10]

Table 1. Melting Point, Laser Threshold for Hole Formation, and Signal-to-Noise Ratio in Read-Out of Different Metals at a Wavelength of 0.488 μm

Metal	Melting point T_m(°C)	Threshold P_r(mW)	Signal-to-noise ratio (dB)
Ti	1668	12	54
Ge	937	9	38
Al	660	15	43
Te	450	3	54
Pb	327	3	36
Bi	271	3	41
In	156	5	40

II. State Transformation Optical Disk Materials

These materials are nonstoichiometric oxides. In the presence of the right reducing agent, a number of oxides form nonstoichiometric oxides (LOx). The optical transmissibility of LOx thin films often decreases under the action of light (Figure 3) or heat (Figure 4). This is the optical (or thermal) blackening phenomenon caused by the changes of the characteristic absorption limit. TeOx is a suitable optical disk material[11] because its saturation ratio is large and it is sensitive to light (Figure 3).

Under laser radiation, the TeOx film not only changes its transmissivity T, but also its refractive index n and its attenuation coefficient k. Along with changes in n and k, the reflectivity of the film also changes. This may be exploited to achieve the read-out purpose. As the content of Te increases, the difference in refractive index and attenuation coefficient before and after the heat treatment increases (Figure 5), the temperature of the change of state decreases (Figure 6), and the chemical stability of the material also decreases.

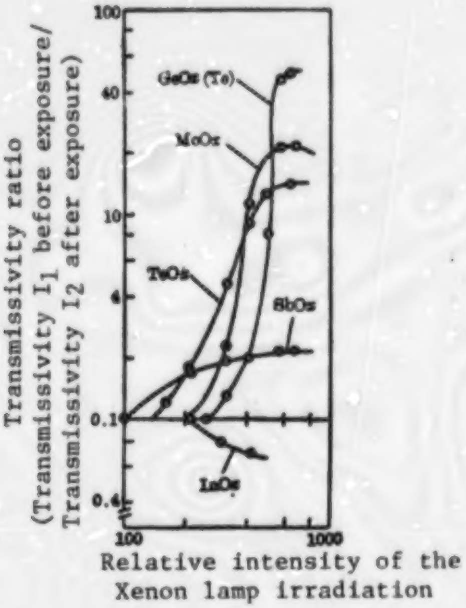

Figure 3. Changes in transmissivity of various metal oxide memory films under Xe lamp radiation

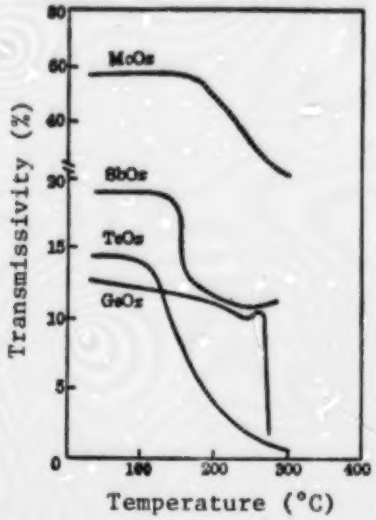

Figure 4. Transmissivity changes of oxide memory films under heating

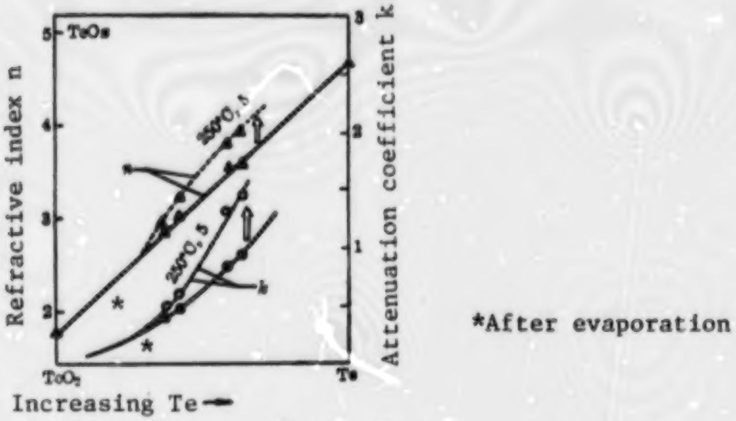

Figure 5. Refractive index and attenuation coefficient of TeOx film as a function of Te content. Solid line: before heat treatment; Dashed line: after heat treatment

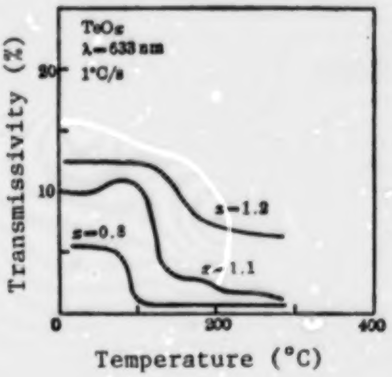

Figure 6. The blackening temperature of TeOx film as a function of composition

Under certain laser irradiation conditions, the optical properties of TeOx films with small amounts of added Ge and Sn become reversible and serve as the basis for erasable optical disks. TeOx:Ge 5 percent, Sn 10 percent optical disks made with a vapor method show a carrier noise ratio of 55 dB for a 5 MHz recording frequency and can be erased 10^6 times.

VO_2 show similar properties, its refractive index and optical absorption coefficient change after thermal treatment and metallic vanadium may precipitate out. Its transformation temperature is low and the change is reversible. It is reported that the properties remain unchanged after 10^8 cycles.[12]

Certain amorphous semiconductors such as sulfide glasses undergo changes in their refractive index and absorption limit under laser radiation. The absorption limit of $As_{40}Se_{50}Ge_{10}$ amorphous film moves toward longer wavelength after it is irradiated for 2 ms by a 10 mW acousto-optically modulated He-Ne laser. After a heat treatment at 200°C, the absorption edge moves toward a shorter wavelength again. By controlling the chemical composition and heat treatment, this reversible reaction may be used in making erasable optical disks.

III. Phase Transformation Type Optical Disk Materials

This type of materials consists of the sulphur series semiconductor glass films. Their negative bulk resistance and their conductivity changes caused by electrical pulses have been utilized in the 1970's to make threshold switches and ROM's.

When an amorphous $Te_{81}Ge_{15}Sb_2S_2$ film is irradiated with an He-Cd laser (0.44 μm) or an Ar^+ laser (0.488 μm), the recording power is 10 mW, the material fuses within 2 μs, and the film becomes polycrystalline after cooling. Using a 20 mW microsecond laser pulse, the amorphous state may be restored.[13] The crystallization temperature of a $Te_{80}Ge_{15}As_5$ film is 75-90°C; small crystallites of Te appear in the high Ge content amorphous phase and the reflectivity drops from 60 percent to 40 percent. The speed of the phase change is very rapid. For a light spot speed of 10^5 cm/s, the theoretical writing rate[14] should be 200 Mbits/s. Optical disks have been made with such sulphur series compounds,[15] the film thickness is 500-1500 Å. The disks are written with a GaAlAs semiconductor laser with a focusing lens of a numerical aperture of 0.4 and the writing speed is 20 linear meters per second. For an interaction time of 1 μs, and a power density of 0.3-1 mW/μm^2, melting and crystallization take place within 50 μs. The light pulse for restoring the amorphous state (erasure) is 0.1 μs long.

Recently developed phase transformation materials include Se-Te-x-y, where x is a stabilizer, usually Ge, Pb, or As, and y is a sensitizer for faster erasure, usually Ga, Sb, Sn, or Bi. Thin films made by sputtering or evaporation can provide 10^6 cycles of crystalline-amorphous transformations. A practical problem of such materials in application is the long erasure time. Even with the help of the sensitizer, the erasure time is still five times longer than the recording time.

IV. Magneto-Optic Optical Disk Materials

The writing of the magneto-optic material makes use of the Curie temperature or the compensation temperature and the reading of the magneto-optic material makes use of the Kerr effect. Table 2 lists some of the important magneto-optic storage media. The amorphous rare earth-transition metal alloys (RE-TM) developed in the mid-1970's have no crystalline boundaries and a low noise figure and their 1 μm domains are quite stable. The recording is done perpendicular to the film surface, the storage density is high, the recording sensitivity is good, the required laser power is low (a few milliwatts), and can be fabricated into large uniform films.

Table 2. Development of Magneto-Optic Storage Materials

	Magnetic material					
Year	Single crystal	Polycrystalline	Amorphous	Mode of storage	Major development	Company
1957		MnBi		T_c recording, observed by hot probe Kerr effect		Bell
1958				T_c recording, using electron beam		
1960				Laser recording proposed	He-Ne laser	IBM
1965	$Gd_3Fe_5O_{12}$ (bulk)			T_{com} recording proposed	Semiconductor laser	
1968		EuO MnBi		High density read and write testing, using gas laser	Magnetic bubble storage	IBM
1972	$Gd_3Fe_5O_{12}$ (film)	CoP(NiFe) MnAlGe			Optical disk	
1973	$(GdYb)_5Al_5O_{12}$	MnGaGe	GdCo	Using gas laser in reflection mode	Vertical recording	
1975		CrO_2 MnTiBi PtCo	TbFe DyFe, TbCo GdFe	Using gas laser, magneto-optic disk	Laser videodisk	NTT NHK
1978	$(TbYb)_3(FeGa)_5O_{12}$ $(SmEr)_3(GaFe)_5O_{12}$		YGdFe GdFeBi GdTbFe	Semiconductor laser, optical disk storage	Laser compact disk (audio), high density magnetic disk	

The RE-TM alloys may be made into amorphous films by sputtering or by evaporation, the components are shown in Figure 7. The film is magnetized during or after its formation and the magnetic flux lines are perpendicular to the film surface. Under a focused laser, the temperature at the recording point exceeds the Curie temperature or the compensation temperature. In the presence of a magnetizing field, the flux at the recording point reverses and forms a domain, as shown in Figure 8.

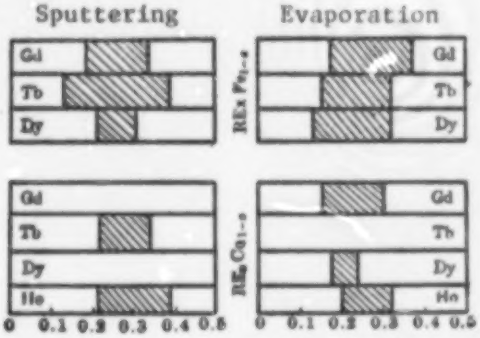

Figure 7. Amorphous RE-TM alloys

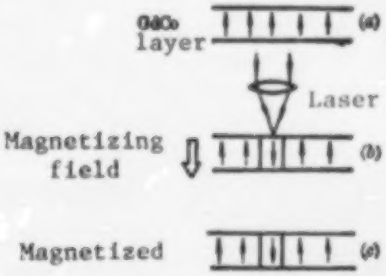

Figure 8. Recording on a magneto-optic thin film

In order to increase the recording density, the film must be magnetized vertically. The condition for a vertical magnetization is:

$$K_u > 4\pi M_s$$

where K_u is the vertical magnetization anisotropy constant, and M_s is the saturation magnetization. The stability of the recording point is:

$$4\pi M_s \left| \frac{1}{2d} - \frac{1}{1+3d/2h} \right| < H_c$$

with He being the coercive force, d being the diameter of the recording spot, l being the characteristic length of the medium and equal to $\sigma_w/4\pi M_s$, where σ_w is the domain wall energy density, and h is the film thickness. When d>>h, the minimum diameter for a stable domain is:

$$d=\sigma_w/2M_sH_c,$$

From a storage density and stability standpoint, the material should have as large as K_u and H_o as possible.[5]

The read-out of the signal makes use of the polarized Kerr rotation effect. When a linearly polarized incident light impinges on the film surface normally, the polarization direction of the reflected light is rotated. The elliptically polarized light is first decomposed into linearly polarized light and the two beams are then received in a differential mode. The received signal intensity is then proportional to the Kerr rotation angle and the signal-to-noise ratio is:

$$S/N\propto\sqrt{R}\,Q_k$$

where R is the reflectivity of the film and Q_k is the Kerr rotation angle. To improve the S/N, the material should have a large Q_k.

Amorphous RE-TM films are obtained by rapid quenching. Thermodynamically the film is in a metastable state and it will crystallize when the temperature is raised. Amorphous materials also undergo a structural relaxation process with a relaxation activation energy of only 0.5 eV. In addition, domain instability may be induced by structural changes and external conditions. When RE-TM films are in contact with oxygen, selective oxidation may occur. The rare earth elements tend to oxidize first and change the film property. In order to have long-term stability, the optical disk material should have thermodynamic, magnetic, and chemical stability.

The rare earth-transition metal alloys may be divided into two classes: the iron series and the cobalt series. The iron series alloys, such as TbFe and DyFe, can be easily made into amorphous films by sputtering or evaporation. Their Curie temperature used for recording does not change with composition greatly (see Figure 9); as a result, compositional inhomogeneities do not affect the film property greatly. The disadvantages of the iron series films are the low level of stability and the small Kerr rotation angle.[16] The cobalt series materials, such as GdCo and DyCo, make use of the compensation temperature in recording. Because of the larger change of the coercive force with temperature (shown in Figure 10), the recording sensitivity is high, the writing temperature is low and stable, and the thermal stability of the material is better than that of the iron series. But because of the large change of the compensation temperature with composition, uniform thin films are hard to make and small recording dots are not stable enough.

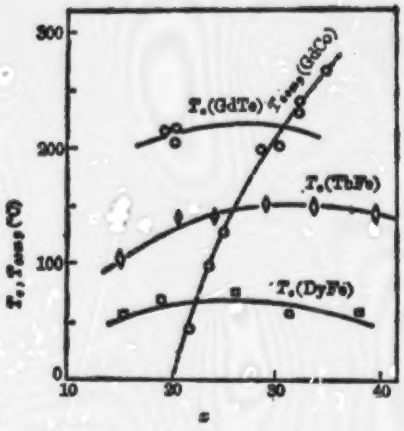

Figure 9. Curie temperature (T_c) of $RE_xFe(100-X)$ and compensation temperature (T_{comp}) of $RE_xCo(100-X)$ as a function of composition

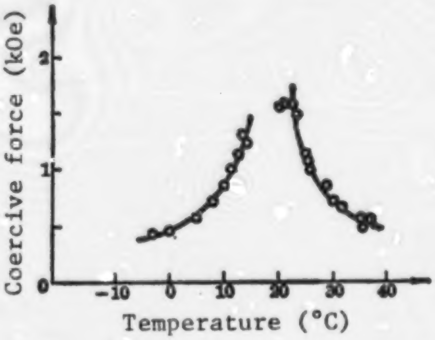

Figure 10. H_c of GdCo as a function of temperature

The Kerr rotation angle of Fe and Co series binary amorphous films is usually 0.3-0.35 degrees. Ternary, quaternary, and pentac amorphous films are currently being studied in the search for a greater Kerr rotation angle. Ternary films usually have a Kerr angle of 0.4 degrees or so. The $(Gd_{50}Tb_{50})_y(Fe_{65}Co_{35})_{1-y}$ quaternary hybrid Fe-Co optical disks[17] with a rotation angle of 0.45-0.5 degrees made their debut in May 1984. Experiments are under way at Osaka University to add a fifth element Sm in GdTbFeCo quaternary material.

In addition RE-TM amorphous films, other amorphous and polycrystalline magnetic materials have also been investigated. Recently polycrystalline PtMnSb alloys[15] are found to have a Kerr rotation of 1.27 degrees at 720 nm and 0.77 degrees at 830 nm, the largest rotation angles to date. Unfortunately, no large area uniform films are yet available. Table 3 shows the properties of various magneto-optic materials.

Table 3. Properties of Magneto-Optic Materials

Material	Amorphous films						Polycrystalline films		
	GdCo	GdFe	TbFe	TbFe—Co	GdTb—Fe	GdFe—Bi	Pt—MnSb	Mn—CuBi	Mn—AlGe
Recording temp (°C)	120 (T_{comp}20)	210	140	200	160	145	210	210	245
Kerr rotation (deg)	0.33	0.35	0.3	0.4	0.4	0.41	0.77	0.43	0.1
Wavelength (nm)	633	633	633	633	830	633	830	830	633

To overcome the chemical instability of RE-TM films (mainly the preferential oxidation of the rare earth elements), researchers have investigated other oxide systems including stoichiometric and nonstoichiometric of rare earth or transition metal oxides, and some iron oxides and garnets.

The oxygen atmosphere is carefully controlled in the film fabrication process to avoid oxidation. Films are usually made in an oil-free vacuum chamber. A transparent protective layer is often added to the RE-TM film to keep the film from getting in contact with oxygen. Most magneto-optic disks are coated with SiO_2. It was discovered recently that oxygen has entered the RE-TM film in the SiO_2 sputtering process and affected the long-term stability of the film. As an improvement, the Central Research Institute of the Sharp Company used AlN film[18] instead of SiO_2 film.

The value of Q_k in single layer RE-TM films is usually small (0.2-0.4 degrees). This may be enhanced by having a multilayer structure. An antireflection film is first laid down to reduce surface reflection losses, a metal film is then placed at the bottom to improve the light energy conversion, finally a thin interference film is used to enhance the output signal.[10] Figure 11 shows the multilayer structure, and Table 4 shows the calculated parameters. Experiments using MnBi films showed that the signal-to-noise ratio of a four-layer film is almost twice that of a single film.[20]

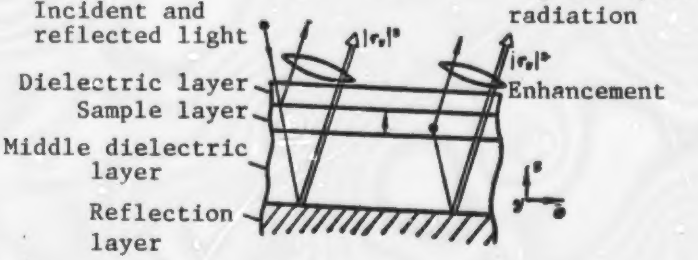

Figure 11. Multilayer magneto-optic film structure

Table 4. Calculated Parameters of Multilayer Magneto-Optic Films

No	Medium layer			
	1	2	3	4
1	—	RE-TM Thick	SiO_2 Thick	—
2	SiO_2 (1200 Å)	RE-TM Thick	SiO_2 Thick	—
3	SiO_2 (1200Å)	RE-TM (1800Å)	SiO_2 (1100 Å)	Al Thick

No	Reflectivity	Kerr rotation Q_k	Ellipticity	Kerr intensity $\lvert r_y \rvert^2 \times 10^4$
1	0.60	0.45	0.22	0.47
2	0.34	1.00	0.54	1.37
3	1.84	1.84	3.24	3.00

A great effort is being made by the Electronics Technology Institute of the Japan Industrial Technology Institute to develop composite magneto-optic films. The composite film is a two-layer RE-TM amorphous film: a TbFe film coated with a GdCo or GdTbCoFe film. The composite film has the superior magnetic properties of the TbFe film such as the high coercive force H_c and the convenient Curie temperature T_c (150°C), and also a large Kerr rotation angle (0.5° or so) comparable to that of a GdTbFeCo film and 2-3 times greater than that of a TbFe film.[2]

Read and write optical disks made of amorphous magneto-optic materials have already been developed in recent years. Table 5 lists the technical parameters of various optical disk materials.

From the analysis above, one can see that the nonerasable optical disks today are mostly the burn-in type multilayer alloy films, although gas bubble type organic gel and dye materials are also under development. Erasable optical disks are still in the research stage. In addition to the phase transformation, change of state, and magneto-optical disks under study, photochromatic, electrochromatic and photovoltaic materials are also being explored. New ideas of optical disk storage media continue to appear and better nonerasable and erasable materials are expected in the development of the optical disk technology.

Table 5. Technical Parameters of Magneto-Optic Disk Components

Company / Parameter	KDD	Sharp	Matsushita	NIIK	NTT	NHK	Sony	Xerox	Philips
Recording medium	TbFe/ GdTbFe	TbDyFe/ GdTbFe	MnCuBi/ GdTbFe	GdCo	MnBi/ MnCuBi	CrO_2	γFe_2O	TbFe	GdTbFe
Recording method	T_c	T_c	T_c	T_{comp}	T_c	T_c	H_c	T_c	T_c
Operating temperature (°C)	140/160	70/150	200/160	70-80	360/200	--	--	--	--
Kerr rotation angle (deg.)	0.3/0.4	0.5/0.7	0.43/0.4	0.3	0.7/0.2	RIG-1	RIG	--	--
Disk diameter (mm)	120/200	140	120	150	135	300	250	76.2	50.8
Substrate material	Glass/ organic glass	Glass	Glass	Glass	Glass	Thin plate	Thin plate	Glass	PMMA
Rotational speed (rpm)	450-1800	720	400	1800	1000-2000	1800	360	1200	600
Light source	GaAlAs	GaAlAs	GaAlAs	He-Ne	Ar	Ar	Magnetic head	LD	LD
Recording power (mW)	5-10	4.5	5	5.6	40-70	30-60	--	4.9	3
Reconstruction light source	GaAlAs	GaAlAs	GaAlAs	He-Ne	Ar	He-Ne	He-Ne	LD	LD
Reconstruction power (mW)	1-2.7	~2	~2	~2	10-25	~10	5.6	--	1
Dimension (μm)	1	1	1	1	2	2x7	5x20	1	2
Channel gap (μm)	2.5	2	5	3-6	5	15	200	2	10
Input/output signal	Digital	Digital	Digital	FM	Digital	FM	FM	--	--
Write-read speed (MHz)	0.5-2	2	2	1-5	0.5	10	1-3	--	--
S/N, C/N (dB)	C/N-45	C/N-40	C/N-40	C/N>35	--	S/N-40	S/N ~	S/N-37	S/N-30
Error rate	$\sim 10^{-5}$	--	--	--	6.28×10^{-6}	--	--	--	--

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APPLIED SCIENCES

CORNEA INJURY BY CO_2 LASER STUDIED

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 12, No 12, 20 Dec 85 pp 739-741

[Article by Xu Jiemin [1776 4309 2404], Zhou Shuying [0719 3219 5391], Hu Fugen [5170 1381 2704], Cao Weiqun [2580 4850 5028], Xu Guidao [1776 6311 6670], Qian Huanwen [6929 3562 2429], Wang Denglong [3769 4098 7893], and Shi Liangshun [2457 5328 7311] of the Institute of Radiation Medicine, Academy of Military Medical Sciences: "Injury Threshold of Cornea by CO_2 Laser Light Exposure"]

[Text] Abstract: The minimal visible lesion in the corneal epithelium resulted from exposure to CO_2 laser light has been carefully determined. The dose to cause 50% damage probability (ED_{50}) varied with time of exposure: for 1.03 s was 5.72 W/cm^2 (95% CL 5.8-5.85 W/cm^2) and for 0.12 s was 10.7 W/cm^2 (95% CL 10.4-10.9 W/cm^2).

CO_2 lasers are widely used in industry, scientific research, medical care and military. In this article we studied the occurrence frequency cornea injury as a function of exposure time and level of irradiation and obtained the injury threshold.

I. Experiment

Figures 1 and 2 depict the experimental irradiation setup. The apparatus consists of a CO_2 laser, a power attenuator, a timing control, a transmission type power monitor, a collimating He-Ne laser, a finite aperture, and an animal irradiation table. The maximum output power is 20 W, the output stability is ±3 percent, the output is an approximate single transverse mode, and the divergence angle is less than 2.5 mrad.

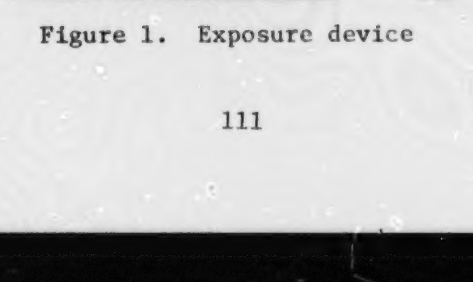

Figure 1. Exposure device

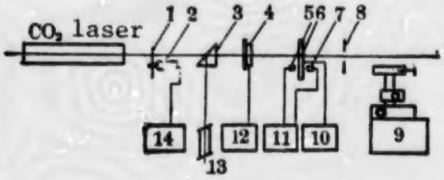

Figure 2. Light path of the exposure device

1. Stainless steel screen
2. D.C. motor
3. Right angle prism
4. Transmission power meter
5. Light source
6. Shutter
7. Photoelectric tube
8. Diaphragm
9. Animal table
10. Timer control
11. Timer
12. 1503 digital meter
13. He-Ne laser
14. Power supply

The exposure time is measured to an accuracy of 0.5 percent or better. Two groups of exposure times with averages of 1.03 s and 0.12 s, respectively, are used. The standard deviations in time measurement are less than ±1 percent and ±5 percent, respectively. The standard deviation in power measurement is less than ±5 percent.

Experimental animals are gray rabbits weighing 2.4-3.7 kg. The corneas are found to be normal in microscopic examinations before the irradiation. The rabbit is placed on a frame with three degrees of freedom and a 1 mm diameter diaphragm is placed in front of the eye to confine the laser beam. Alignment is achieved with an He-Ne laser along the same optical path. Examinations are made with a crevasse lamp and a microscope within 10 minutes after the exposure. Some of the eyeballs are removed for pathological examination. A total of 854 exposure spots on 142 rabbit eyes are made in 11 groups. The average exposure time is 1.03 seconds for the first six groups and 0.12 seconds for the remaining five groups.

II. Results

1. The damages caused by the average power density of 4.17-13.4 W/cm^2 used in our tests are all superficial minor injuries confined to the top layer of the cornea. Circular gray or light gray injury spots were observed. Light injuries showed as light gray points or crescent spots with a white point in the middle. Most of the injury spots disappeared within 16-24 hours after the exposure. Gray injury spots faded considerably after 48-72 hours.

2. The cornea injuries were studied as a function of exposure dose and exposure time. Two exposure times were used and the injury results for 11 sets of tests are given in Table 1. As can be seen, the frequency for cornea injury increases with the average power density. For the same level of injury, the power density decreases as the exposure time increases.

Table 1. CO_2 Laser Exposure Dose, Time and Cornea Injury Frequency

Test No.	Average exposure time (sec)	Dosage: Average energy density (J/cm^2)	Dosage: Average power density (W/cm^2)	Injury frequency: Injury/sample points	Injury frequency: Percent
1	1.0463	8.32	7.95	50/50	100
2	1.0251	7.07	6.89	61/66	92.4
3	1.0240	6.62	6.47	70/82	85.4
4	1.0233	6.04	5.90	25/50	50.0
5	1.0215	5.50	5.39	26/72	36.1
6	1.0232	4.27	4.17	2/102	1.96
7	0.1209	1.62	13.4	62/70	88.6
8	0.1218	1.45	12.0	47/60	78.3
9	0.1211	1.31	10.9	34/60	56.7
10	0.1219	1.24	10.1	68/192	35.4
11	0.1280	0.972	7.59	4/50	8.0

3. Cornea injury threshold calculation: The cornea injury threshold ED_{50} for CO_2 laser usually refers to the exposure dosage for 50 percent probability observable injury within 10 minutes after the exposure. Experimental results show that, for an exposure time of 1.03 seconds, the regression equation is:

$$\hat{Y}=16.66x-7.611$$
$$ED_{50}\simeq 5.72\ W/cm^2$$

(95 percent confidence level is 5.58-5.85 W/cm^2)

For an average exposure time of 0.12 seconds, the regression equation is:

$$\hat{Y}=11.77x-7.087$$
$$ED_{50}\simeq 10.7\ W/cm^2$$

(95 percent confidence level is 10.4-10.9 W/cm^2)

III. Pathological and Histological Observation of Injuries

Physiopathological and histological observations of 23 rabbit eyes show that, for the radiation level used in this study, the injuries of the cornea are coagulation of the three focal regions:

1. Central necrosis region: At the center of the burned cornea, cell coagulate leads to necrosis and local epithelium detachment. This injury may vary in size and location, but occurs mostly at the center of the affected region. It may also occur to one side of the center, possibly due to the variation of the "hot spot" of the CO_2 laser. In serious cases, the entire epithelium is detached and a flat bottom or conical pit is formed. In lighter injuries the epithelium cells flake off and leave islands. The substrate layer shows no observable changes.

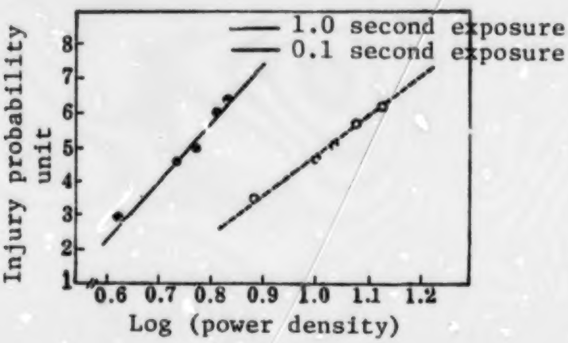

Figure 3. CO_2 laser exposure dose, exposure time, and frequency of cornea injury. Solid line: 1.035 seconds, dashed line: 0.125 seconds.

2. Surrounding coagulation region: The level of injury decreases as the light intensity decreases toward the surrounding. Injuries of the region surrounding the necrosis are mostly cell coagulation and shrinkage, decoloration and fragmentation of the nuclei are observed.

3. Peripheral edema and coagulation region: At the peripheral of the focal region the flat or wing-shaped cells of the shallow epithelium layer show swelling or coagulation and nuclear wrinkling is observed.

The degree of injury varies with the irradiation dosage. Severe injuries are associated with large area of damage and extensive necrosis. Light injuries show no necrosis and only epithelium coagulation, as shown in Figure 4. Very slight injuries are small and shallow and extend only to the shallow layer of cells. Some focal regions have the appearance of a disk with a diameter of 200-300 μm. Injuries occurring at the threshold level are mostly light or very light.

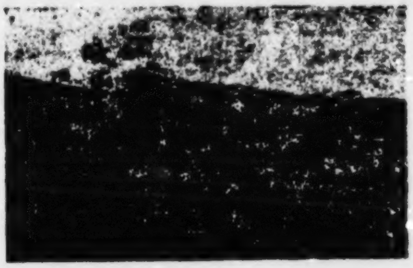

Figure 4. Cornea epithelium cell damage caused by CO_2 laser

The authors thank Tang Zhongming [3828 0112 2494] for his assistance in statistical data analysis using a computer.

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APPLIED SCIENCES

LASER PULSE COMPRESSOR AND PHASE-COMPENSATOR DESCRIBED

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 12, No 12, 20 Dec 85 pp 750-751

[Article by Wu Cunkai [0702 1317 1956], Lan Guang [5663 0342], Xu Jie [1776 2212], and He Guozheng [0149 0948 3791]: "Laser System With Pulse-Compressor and Phase-Compensator"]

[Text] In the development of nonlinear phase conjugate optics, a number of phase conjugate cavity[1] and phase conjugate mirrors[2] have been proposed for the phase anomaly in the laser amplifier. In Ref. 3 a composite laser system with a stimulated Brillouin scattering (SBS) conjugate mirror was studied and 200 mJ of output was obtained using a polarization isolation technique. In Ref. 4, pulse compression was observed using the usual capillary Brillouin cell and using a ruby laser as a pump. In Ref. 5, higher order pulse compression was achieved with a long conical capillary Brillouin cell. In this work, we combined the composite laser system in Ref. 3 and the conical capillary Brillouin scattering conjugate mirror. Using a polarization isolation method, the compressed laser pulse is completely coupled out. Using a 670 mm tapered capillary Brillouin cell containing CS_2 liquid, the pulse width of the Q-switched Nd:YAG laser amplifier in the composite system is compressed by a factor of 3. The laser pulse energy is more than 240 mJ. The degree of compression depends on the length of the capillary; by changing the length of the Brillouin cell, it is possible that a variable pulse width laser can be made.

Figure 1 shows the composite laser system. The total reflection mirror M_1 and the coated glass plate M_0 constitute the Nd:YAG oscillator cavity. An irradiated LiF crystal is used as the Q-switch. The Q-switched output pulse has a full width at half maximum of 30 ns.

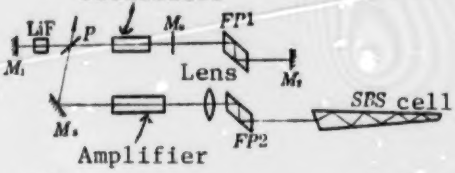
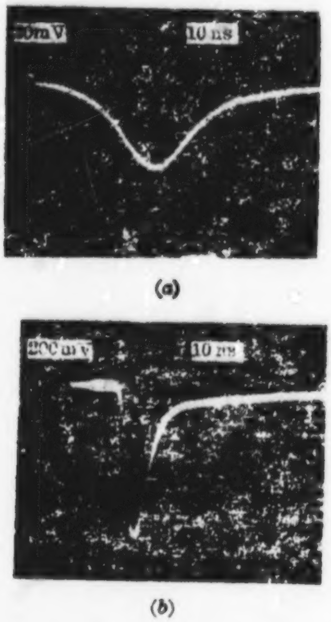


Figure 1. A composite laser system with a conical capillary SBS conjugate mirror

A polarizer P is inserted into the cavity as a coupler. The polarizer reflects all the S-component and transmits all the P-component. The oscillator output goes through the Fresnel prism FP1 and turns into a circularly polarized light. It then reflects from M_2 and passes through FP1 one more time and becomes an S-polarized light. The light is amplified by the laser medium of the oscillator, reflected by the polarizer P into the Nd:YAG amplifier, focused by the long focal length lens, and turned into a circularly polarized light by another Fresnel prism FP2 before it enters the 670 mm conical capillary. The incident diameter of the capillary is 8 mm and the exit diameter is 1.5 mm. The capillary is filled with a CS_2 liquid. Since CS_2 has a large refractive index (n = 1.63), the light beam propagates in the capillary by total internal reflection. Because the SBS conjugate mirror does not have a polarization inversion, the back scattered light remains circularly polarized but the sense of rotation is opposite to that of the incident circularly polarized light. As a result, when the back wave passes through FP2 again, it becomes a light of P-polarization. This conjugate wave goes through the amplifier medium for a second time, the phase anomaly of the medium is compensated and the output is coupled out by the polarizer P. The energy of the laser pulse entering the Brillouin cell is about 240 mJ. For a focal length of 1.3 m, the output energy of the composite laser system is about 160 mJ. The output energy can be easily varied by changing the focal length of the lens. At a focal length of 800 mm, the output is 230 mJ or so. Figure 2(a) shows the input laser pulse waveform of the Brillouin conjugate mirror, the full width at half maximum is about 30 ns. Figure 2(b) shows the output waveform of the composite system, the full width at half maximum is about 10 ns. The pulse width compression factor is 3.



(a)

(b)

Figure 2. (a) Incident wave of the conical Brillouin scattering cell
(b) Output wave of the composite laser system

Using a regular SBS cell, a backward wave cannot be obtained by a lens with a focal length greater than 500 mm under our experimental conditions. The conical Brillouin cell not only compresses the pulse width but also allows the use of longer focal length lens due to the compression of the light beam in the capillary tube. This has prevented damages of the Brillouin cell, an important practical consideration. Furthermore, the present system can deliver several tens of millijoules of backward wave even without the help of a focusing lens.

Figure 3 shows the near-field and far-field patterns of the composite laser system. The divergence of the output is better than 2×10^{-3} rad. The divergence angle of a laser without phase compensation is about 3×10^{-3} rad.

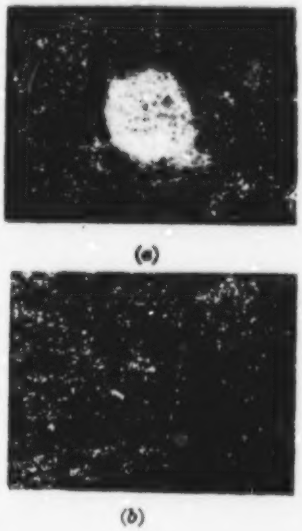


Figure 3. (a) Near-field and (b) far-field pattern of the composite laser output

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APPLIED SCIENCES

STANDING WAVE WIGGLERS USED IN FREE-ELECTRON LASER

Shanghai HONGWAI YANJIU [CHINESE JOURNAL OF INFRARED RESEARCH] in Chinese
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[Article by Lei Shizhan [7191 0099 3277]: "A Free-Electron Laser with Standing Wave for Wigglers"]

[Text] Abstract: Operating condition for free-electron lasers with standing wave for wigglers are analyzed and the laser gains are calculated.

I. Introduction

A unique feature of free electron lasers is that the output wavelength can be tuned continuously by changing the energy of the relativistic electrons and the spatial period of wiggler. In principle, output can be obtained in the infrared, ultraviolet, and even the X-ray range. The wavelength of the laser is[1]

$$\lambda_r = \frac{\lambda_w(1+K^2)^{-1}}{2\gamma^2}, \qquad (1)$$

where K is a constant determined by the wiggler parameters, γ is a relativistic factor equal to the ratio of the electron energy and mass m_0c^2, and λ_w is the spatial period of the wiggler. As can be seen, a high energy relativistic electron beam is required to produce short wavelength laser. Recently attempts have been made to obtain laser oscillation in the X-ray wavelength[2] using free electron laser but great technical difficulties were encountered.

Another approach to obtain short wavelength radiation is to shorten the period λ_w of the wiggler. For example, if the spatial period of the wiggler of a 54 MeV relativistic electron beam is 10μ m, then the radiation wavelength of the free electron laser will be in the X-ray range. However, it is exceedingly difficult to construct a wiggler with a period in the micrometers using conventional static magnetic or electric fields. In this paper we propose that microwave or laser radiation standing waves be used as a wiggler to achieve a spatial period of micrometers or even shorter.

II. Basic Equations

Suppose a wiggler is established by standing wave radiation in the z direction with a wavelength λ_w, the magnetic field B_w and electric field E_w of the wiggler

$$B_w = B_w[\hat{x}e^{-i(k_w z+\varphi_w)} - i\hat{y}e^{-i(k_w z+\varphi_w)}] + c.\ c., \quad (2)$$

$$E_w = E_w[\hat{x}e^{i(k_w z+\varphi_w)} - i\hat{y}e^{i(k_w z+\varphi_w)}] + c.\ c. \quad (3)$$

are respectively where B_w and E_w are the standing wave amplitudes, $k_w = 2\pi/\lambda_w$, φ_w is the initial phase, and $\hat{x}$ and $\hat{y}$ are unit vectors in the transverse direction.

If the lateral linewidth of the relativistic electron beam is small enough, the lateral variation of the wiggler field and the radiation field can be neglected and the vector potential $\vec{A_w}$ of the wiggler may be written as

$$A_w = [A_w e^{-i(k_w z+\varphi_w)} + A_w e^{i(k_w z+\varphi_w)}]\hat{e} + c.\ c., \quad (4)$$

where A_w is the amplitude of the wiggler field and $\hat{e} = \hat{x} - i\hat{y}$. The radiation field vector potential A_r may be written as

$$A_r = [A_r e^{i(k_r z-\omega_r t+\varphi_r)} + A_r e^{-i(k_r z-\omega_r t+\varphi_r)}\hat{e} + c.\ c., \quad (5)$$

where A_r is the amplitude of the vector potential $\vec{A}_r$, $k_r = 2\pi/\lambda_r$, λ_r is the wavelength of the radiation field, ω_r is the circular frequency of the radiation field, and ϕ_r is the initial phase of the radiation field.

The Hamiltonian of the relativistic electron is

$$H = c[(P - eA)^2 + m_0 c^2]^{\frac{1}{2}} - \gamma m_0 c^2, \quad (6)$$

where P is the eign momentum of the relativistic electron, m_0 is the rest mass of the electron, and c is the speed of light. The equation of motion of the Hamiltonian operator is

$$\left.\begin{aligned} p_i &= -\frac{\partial H}{\partial q_i}, \\ q_i &= \frac{\partial H}{\partial p_i} \end{aligned}\right\} \quad (7)$$

where p_i are the three components of the eign momentum of the relativistic electron and q_i are the three position coordinates. Substituting (3) and (4) into (5), we find from (7) that

$$\dot{p}_x = -\frac{\partial H}{\partial x} = 0,$$

$$\dot{p}_y = -\frac{\partial H}{\partial y} = 0.$$

That is, the transverse eign momentun is a constant and is determined by the initial conditions. If the electrons enter the wiggler with a zero transverse velocity ($v_\perp = 0$), then the constant may be taken to be zero of $\vec{P}_\perp = 0$. This shows that the dynamic transverse momentun of the electron is

$$P_\perp = -eA = m_0 c\gamma\beta_\perp, \quad (8)$$

where $\beta_\perp = \frac{v_\perp}{c}$. From (8), we obtain the transverse velocity unit vector:

$$\beta_\perp = -\frac{eA}{m_0 c\gamma}. \quad (9)$$

The motion of the electron in the wiggler is described by the Lorentz equation of motion:

$$\frac{d\gamma}{dt} = -\frac{e}{m_0c}\,\beta\cdot E, \tag{10}$$

$$\frac{d}{dt}(\gamma\beta) = -\frac{e}{m_0c}[E+c\beta\times B]. \tag{11}$$

from (10) and (11), we have

$$\frac{d}{dt}(\gamma\beta_z) = \frac{d}{dt}\,\gamma, \tag{12}$$

where β_z is the z component of $\vec{\beta}$. Upon integrating (12), we have

$$\gamma(1-\beta_z) = \gamma_0(1-\beta_{z0}), \tag{13}$$

where γ_0 is the relativistic factor of the electron entering the wiggler, $\gamma_0 = (1-\beta_{z0})^{-\frac{1}{2}}$; $\beta_{z0} = v_{z0}/c$, v_{z0} is the longitudinal velocity of the electron upon entering the wiggler.

From (10), we have

$$\frac{d\gamma}{dt} = -\frac{e}{m_0c}\,\beta_\perp\cdot E_\perp. \tag{14}$$

By substituting (9) into (14), we have

$$\frac{d\gamma}{dt} = \frac{e^2\gamma}{m_0c^2\gamma}\,A_\perp\cdot E_\perp. \tag{15}$$

Substituting (4) and (5) into (15), we have

$$\frac{d\gamma}{dt} = \frac{e^2\gamma}{m_0^2c^2\gamma}\,A_wE_r[\sin\theta+\cos\theta]. \tag{16}$$

where $\theta = (k_w-k_r)z+\omega_rt+\varphi_B-\varphi_r.$

Equation (16) shows that the energy of the relativistic electron is not a constant even at the resonance frequency (i.e. $\dot\theta = 0$) and that is different from the case of a spatially periodic statis magnetic field wiggler. Taking the time derivative of θ, we have

$$\dot\theta = (k_w-k_r)c\beta_z+\omega_r. \tag{17}$$

Therefore, the relativistic electrons emit radiation as long as the logitudinal velocity v_z satisfies the condition

$$v_z < \frac{c(\omega_w+\omega_r)}{\omega_r},$$

and the phase between the electron motion and the vector potential satisfies $\frac{\pi}{4}<\theta<\frac{5\pi}{4}$. The radiation power is a maximum when the phase $\theta = \frac{3\pi}{4}$

The electrons are accelerated by the wiggler field when $\frac{5\pi}{4}<\theta<2\pi$ or $0<\theta<\frac{\pi}{4}$ At $\theta = \frac{7}{4}\pi$, the electrons absorb the maximum amount of energy from the wiggler field, when $\theta = \frac{\pi}{4}$ or $\theta = \frac{5}{4}\pi$ the electrons do not emit radiation and do not absorb energy from the wiggler field, the energy of the electron remains a constant.

III. Results and Discussion

Since the electron energy in the wiggler do not change very much, the relative factor γ may be written as

$$\gamma=\gamma_0+\delta\gamma_1+\delta\gamma_2+\cdots, \tag{18}$$

where $\delta\gamma_1$、$\delta\gamma_2\cdots$ are respectively first order small quantity, second order small quantity and so forth. From (13), the longitudinal velocity vector β_z may be approximately written as

$$\beta_z=1-\frac{\gamma_0}{\gamma}(1-\beta_{z0})\doteq\frac{\delta\gamma_1}{\gamma_0}(1-\beta_{z0})+\beta_{z0}. \tag{19}$$

In order to find the gain of the free electron laser, we first find the first order small quantity $\delta\gamma_1$. From (16) we have

$$\delta\dot{\gamma}_1=\frac{e^2}{\gamma_0 m_0 c^2}A_w E_r[\sin(\theta_0+\theta_0')+\cos(\theta_0+\theta_0')], \tag{20}$$

where
$$\theta_0=[(k_w-k_r)c\beta_{z0}+\omega_r]t,$$
$$\theta'_0=\varphi_s-\varphi_r.$$

By integrating (20), we have

$$\delta\gamma_1=\frac{e^2A_wE_r}{(k_w-k_r)c\beta_{z0}+\omega_r}[\sin\theta_0-\cos\theta_0-\sin\theta_0'+\cos\theta_0']. \tag{21}$$

since θ_0' may assume any value, the average value of $\delta\gamma_1$ from 0 to 2π gives $\langle\delta\gamma_1\rangle=0$. The second order small quantity $\delta\gamma_2$ is therefore needed in finding the gain of a free-election laser. From (16), we have

$$\gamma_0\delta\dot{\gamma}_2=\frac{e^2}{m_0^2c^2}A_wE_r[\sin(\theta_0+\theta_0'+\delta\theta_0)+\cos(\theta_0+\theta_0'+\delta\theta_0)]-\gamma_0\delta\dot{\gamma}_1, \tag{22}$$

where
$$\delta\theta_0=\frac{(k_w-k_r)c(1-\beta_{z0})\delta\gamma}{\gamma_0}t.$$

Using trigonometric expansions of $\sin(\theta_0+\theta_0'+\delta\theta_0)$ and $\cos(\theta_0+\theta_0'+\delta\theta_0)$, and keeping in mind that $\theta_0\gg\delta\theta_0$, we have

$$\left.\begin{aligned}\sin(\theta_0+\theta_0'+\delta\theta_0)&\doteq\delta\theta_0\cos(\theta_0+\theta_0')+\sin(\theta_0+\theta_0'),\\ \cos(\theta_0+\theta_0'+\delta\theta_0)&\doteq\cos(\theta_0+\theta_0')-\delta\theta_0\sin(\theta_0+\theta_0').\end{aligned}\right\} \tag{23}$$

Substituting (20) and (21) into (22), making use of (23), integrating with respect to time t, and finding the average of θ_0' in the $0\sim 2\pi$ range, we have

$$\begin{aligned}\langle\delta\gamma_2\rangle=\mathscr{A}\{&\cos[(k_w-k_r)c\beta_{z0}+\omega_r]t\\ &+[(k_w-k_r)c\beta_{z0}+\omega_r)]t\sin[(k_w-k_r)c\beta_{z0}+\omega_r]t-1\}.\end{aligned} \tag{24}$$

Here

$$\mathscr{A}=\left(\frac{e^2A_wE_r}{m_0^2c^3\gamma_0}\right)^2\frac{(k_w-k_r)c(1-\beta_{z0})}{[(k_w-k_r)c\beta_{z0}+\omega_r]^2}. \qquad (25)$$

Let $\psi=[(k_w-k_r)c\beta_{z0}+\omega_r]t,$ (24) simplified to

$$\langle\delta\gamma_2\rangle=\mathscr{A}[\cos\psi+\psi\sin\psi-1]. \qquad (26)$$

The radiation energy of a free-electron laser comes from the energy of the realtivistic electrons. If the flux of the electron beam is n_e, the radiation flux I_r of the free-electron laser will be

$$I_r=-\Delta\gamma m_0c^2n_e=-\langle\delta\gamma_2\rangle m_0c^2n_e. \qquad (27)$$

Substituting (26) into (27), we obtain the parametric relationship of the radiation flux density of the free-electron laser and the wiggler:

$$I_r=-\mathscr{A}[\cos\psi+\psi\sin\psi-1]m_0c^2n_e. \qquad (28)$$

The incident flux density I_0 is

$$I_0=\frac{c}{4\pi}E_0^2. \qquad (29)$$

Using (28) and (29), we obtain the gain coefficient of the free-electron laser using a standing wave wiggler:

$$G=-\mathscr{A}4\pi m_0cn_e[\cos\psi+\psi\sin\psi-1]. \qquad (30)$$

At the zero of time, $\psi\ll1$, and (30) gives

$$G=-4\pi m_0c\mathscr{A}n_et^2[(k_w-k_r)c\beta_{z0}+\omega_r]^2. \qquad (31)$$

Equation (31) shows that in the beginning stage the gain coefficient G is proportional to the square of time t. Also, to obtain a positive gain one must satisfy one of the following inequalities:

$$k_r>k_w$$

or

$$\lambda_w>\lambda_r.$$

Finding the average gain under such conditions for a phase range of 0 to $\pi/2$, we have

$$\overline{G}_{0\sim\frac{\pi}{2}}=-4(4-\pi)m_0cn_e\mathscr{A}. \qquad (32)$$

Over the range of $\pi/2$ to π, the average gain is

$$\overline{G}_{\frac{\pi}{2}\sim\pi}=-8m_0cn_e\mathscr{A}\left(1+\frac{\pi}{2}\right). \qquad (33)$$

For $\psi=\pi$ to $3/2\,\pi$, we have

$$\overline{G}_{\pi\sim\frac{3\pi}{2}}=8m_0n_ec\mathscr{A}\left(2-\frac{\pi}{2}\right). \qquad (34)$$

For $\psi = 3/2\pi$ to 2π, we have

$$\bar{G}_{\frac{3}{2}\pi\sim\pi} = -4m_0 c n_e \mathscr{A}(5\pi-4). \qquad (35)$$

Equations (32) through (35) show that the condition for a gain in the $\psi=0\rightarrow\pi$ range is

$$\lambda_w>\lambda_r,$$

and the condition for a gain in the $\psi=\pi\rightarrow 2\pi$ range is

$$\lambda_w<\lambda_r.$$

Generally speaking, $\lambda_w>\lambda_r$ is easy to satisfy and $\lambda_w<\lambda_r$ is not. The operating condition should therefore be chosen in the $\psi=0\rightarrow\pi$ range. For a given wiggler field and electron beam, this condition is equivalent to requiring the light pulse duration satisfying.

$$t<\frac{\pi}{k_w c\beta_{e0}+(1-\beta_{e0})\omega_r}. \qquad (36)$$

Equation (36) shows that the pump time must be shorter for short radiation wavelength. The situation is similar to the emission of laser by the atoms: for a short wavelength the lifetime of the energy level must be short, the pumping pulse should be short and the pumping power must be high.

Finally we estimate the laser gain for a given set of operating conditions. We choose a standing wave spatial period λ_w of 1 mm, a radiation power density of 1 kW/cm^2, a realtivistic electron beam with $\gamma = 100$, a electron beam current density of 10 A/cm^2, and an incident light radiation power density of 10^4 kW/cm^2, Based on Eq (1), such a wiggler and relativistic electron beam may amplify a radiation of wavelength 5000 Å. The average gain obtained from Eq (30) is 0.5/cm, comparable to that obtained from a free-electron laser with a conventional static magnetic field wiggler.

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$^{14}CO_2$ ISOTOPE LASER DESCRIBED

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 12 No 9, 20 Sep 85 pp 524-527

[Article by Fei Lin [6316 2651], Wang Kejun [3769 0344 0193] and Zhu Xuhui [6175 2485 6540]: "A $^{14}CO_2$ - $^{12}CO_2$ Isotope Laser"]

[Text] Abstract: A $^{14}CO_2$ - $^{12}CO_2$ isotope laser has been developed and 80 laser lines were measured. Forty lines originated from lasing transition of $00^01-(10^00, 02^00)_I$ band of $^{14}CO_2$ and the strongest line output power was over 4.0 W. The competition effect between isotopes were experimentally observed and domination of lasing radiation of $^{14}CO_2$ was found even when the content of $^{14}CO_2$ was less than $^{12}CO_2$.

I. Introduction

The CO_2 laser was invented by C.K.N. Patel in 1964[1] and the first CO_2 isotope laser was developed by I. Wieder and G.B. McCurdy[2,3] in 1966 using $^{12}C^{18}O_2$. The $^{13}CO_2$ and $^{14}CO_2$ lasers were subsequently developed respectively by G.B. Jacobs and H.C. Bowers[4] and J.C. Siddoway.[5] Extensive calculations and measurements have been made on the transition spectral lines of pure isotope CO_2 lasers. In this article we present a study of the $^{14}CO_2$-$^{12}CO_2$ laser.

II. Experimental Setup

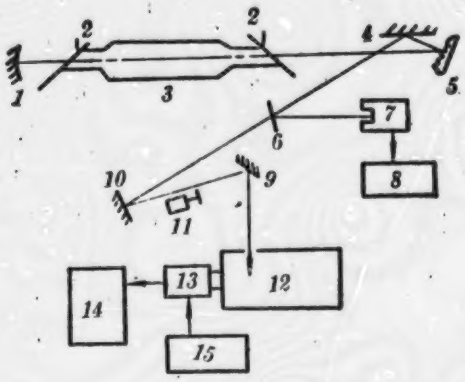

Fig. 1. Experimental Setup

[description on following page]

1. Gold plated total reflection mirror, R = 3m or 5m; 2. NaCl crystal Brewster window; 3. Quartz discharge tube; 4. Aluminum plated planar reflecting mirror; 5. Planar grating; 6. Aluminum plated planar reflecting mirror (installed while measuring laser power); 7. Carbon; 8. Power monitor; 9, 10. Aluminum plated plane mirrors; 11. Chopper; 12. Infrared grating spectrometer; 13. Thermoelectric detector; 14. Oscilloscope, and 15. DC regulated power supply

The experimental steup is shown schematically in Figure 1. The apparatus includes a 1-meter-long water-cooled quartz tube with an inner diameter of 10 mm and a discharge zone 85 cm long. The two ends are NaCl Brewster windows. The apparatus has an external cavity structure. One end has a gold plated total reflection mirror with a radius of curvature of 3 m or 5m, the other end has a planar diffraction grating and the laser output makes use of the zeroth order coupling. The 80 line/mm metal grating has a wavelength of 11 μm, the 75 line/mm grating has a wavelength of 10 μm, and the cavity length is 173 cm. The laser output goes through a chopper and an aluminum planar reflecting mirror and is projected onto an infrared spectrometer with a resolution of 0.25 cm^{-1}. The relative intensity of the laser spectral lines is measured with a RO-L thermoelectric infrared detector. The laser power is measured with a powermeter. The abundance of the radioactive $^{14}CO_2$ gas used in the experiment is about 60 percent and is provided by the Atomic Energy Institute of the Chinese Academy of Sciences. A special gas mixer vacuum system is used to blend the $^{14}CO_2$ and $^{12}CO_2$ gas with N_2 and He. The $^{14}CO_2$ gas is recovered with liquid nitrogen cooling and the residual gas is handled with a cold trap containing NaOH.

III. Results and Discussion

1. Measurement of spectral lines

The experimental conditions are current I = 8 mA, discharge voltage = 16.5 kV, total pressure in the cavity = 18.7 ± 0.2 Torr, and $CO_2:N_2:H_e=1:1:4.2$, $^{14}CO_2:^{12}CO_2$ = 60%:40%. Using an 80 line/mm metal grating, we observed 40 spectral lines of the P branch [P(4) $\sim$ P(42)] and the R branch [R(4) $\sim$ R(42)] of the $00^{0}1-(10^{0}0,02^{0}0)_I$ band (hereafter the I band for short), including the P(4) line with $\bar{\nu}$ =862.97 cm^{-1}. To our knowledge this line has not been observed before and the wavenumber is in good agreement with the calculated values of Freed et al of the Lincoln Laboratory in the United States. In addition we have also observed 22 spectral lines in the P branch [P(10) $\sim$ P(34)] and the R branch [R(12) $\sim$ R(28)] of the I band. Table 1 shows the spectral lines measured with the $^{14}CO_2$ laser and the values measured by Freed et al using a beat method. As can be seen, the agreement is good. The output powers of the P(20) and R(20) lines of $^{14}CO_2$ are above 4.0 W and can still be made higher.

When a 75 line/mm metal grating is used for frequency selection, we observed 17 lines in the P branch [P(12) $\sim$ P(30)] and the R branch [R(12) $\sim$ R(24)] of the $^{12}CO_2$ $00^{0}1-(10^{0}0,02^{0}0)_{II}$ band, and the R(10) line of the $^{12}CO_2$ I band. Since the grating has a wavelength of 10 μm, it is not in favor of the $^{14}CO_2$ oscillation and the number of $^{14}CO_2$ spectral lines is less. Also, because of the decrease in the zeroth order coupling output of the grating, the laser output powers of $^{12}CO_2$ and $^{14}CO_2$ are reduced substantially. However, the spectral line intensities of the $^{14}CO_2$ laser are still greater than the corresponding lines of the $^{12}CO_2$ laser.

In our experiment we have never observed the $^{14}CO_2$ laser transition in the $00^01-(10^00,02^00)_{II}$ band. This indicates that the gain coefficient of this band is too small, consistent with the conclusion in Ref. 7. Table 2 lists the small signal gain coefficients of pure isotopes given in Ref. 7. As can be seen, the gain of the $^{14}CO_2$ $00^01-(10^00,02^00)_{II}$ band is very small. The main reason for the small gain coefficient is that the Fermi resonance plays a dominating role.[8]

2. Isotope competition effect

Figure 2 shows that there are more spectral lines in the $^{14}CO_2$ I band and the line intensities are greater than the spectral lines in the $^{12}CO_2$ band. When the ratio of $^{14}CO_2$ and $^{12}CO_2$ is changed, we find that even when the content of $^{14}CO_2$ is reduced from 60 percent to 40 percent and the grating wavelength is 10 μm (unfavorable for the $^{14}CO_2$ laser oscillation), the output spectral lines of $^{14}CO_2$ still do not change very much and the laser radiation remains dominating. For example, the output power of the R(20) line in the $^{14}CO_2$ I band is still three times greater than that of the R(20) output of $^{12}CO_2$.

Table 1 shows that when $^{12}CO_2$ and $^{14}CO_2$ exist alone, the small signal gain of P(20) in the $^{12}CO_2$ I band is about twice the small signal gain of the $^{14}CO_2$ spectrum. When the gas is a mixture of $^{14}CO_2$ and $^{12}CO_2$, however, the experimental observation shows that the reverse is true.

We believe that this is the result of an isotope competition effect. Similar effects have been observed in a $^{12}CO_2$-$^{13}CO_2$ isotope laser by Green et al.[9] Their interpretation also applies to our case.

The probability for resonance energy exchange between the two isotopes of CO_2 is very high,[10,11] and there is a strong coupling between them. When the higher energy level (00^01) of $^{14}CO_2$ and $^{12}CO_2$ each undergoes population inversion, a Boltzmann equilibrium is quickly reached between the isotope molecules of the higher energy level. Since the vibrational energy of the higher energy level of the $^{14}CO_2$ laser is lower[5] than that of the $^{12}CO_2$ laser by about 123 cm^{-1}, the Boltzmann distribution becomes even more favorable for the upper energy level of the $^{14}CO_2$ laser.

In addition, the CO_2 molecule will dissociate in the discharge:

$$CO_2 \rightleftarrows CO + 1/2\ O_2$$

The CO isotope molecules formed in the dissociate will also exchange energy with the CO_2 molecules. Based on the energy levels of the CO_2 molecule obtained by J. Siddoway,[5] the energy of the first excited vibrational state of the CO isotope molecule obtained by E. Player et al,[12] and the molecular vibrational energy calculations made by Herzberg, we estimated that the vibrational energies of ^{12}CO (v = 1) and ^{14}CO (v = 1) are lower than the vibrational energies of $^{14}CO_2$ (00^01) by 83 cm^{-1} and 172 cm^{-1} respectively,[12] and lower[2] than the $^{12}CO_2(00^01)$ vibrational energy by 206 cm^{-1} and 295 cm^{-1} respectively. As shown in Figure 3, the vibrational states of ^{12}CO and ^{14}CO are closer to the vibrational state of $^{14}CO_2$, making it more favorable to the population distribution of the upper energy state of the $^{14}CO_2$ laser. The final result is that the laser radiative transition of $^{14}CO_2$ dominates the $^{14}CO_2$-$^{12}CO_2$ isotope laser.

Table 1. Laser Spectral Lines of $^{14}CO_2$

$00^01-[10^00, 02^00]_I$					
R branch			P branch		
LINE	Measured ±0.25 [cm^{-1}]	Ref.[6] [cm^{-1}]	LINE	Measured ±0.25 [cm^{-1}]	Ref.[6] [cm^{-1}]
4	869.96	869.69	4	862.97	862.99*
6	871.44	871.47	6	861.42	861.40
8	873.04	871.96	8	859.78	859.79
10	874.32	874.43	10	858.14	858.16
12	875.81	875.88	12	856.52	856.52
14	877.32	877.32	14	854.79	854.86
16	878.61	878.74	16	853.18	853.18
18	880.35	880.15	18	851.58	851.48
20	881.55	881.54	20	849.78	849.78
22	882.86	882.91	22	848.00	848.06
24	884.28	884.27	24	846.32	846.32
26	885.60	885.61	26	844.55	844.56
28	886.93	886.93	28	842.80	842.79
30	888.26	888.23	30	841.05	841.00
32	889.59	889.52	32	839.21	839.20
34	890.93	890.79	34	837.39	837.37
36	892.17	892.04	36	835.57	835.54
38	893.40	893.28	38	833.67	833.68
40	894.65	894.50	40	831.88	831.81
42	895.78	895.70	42	830.00	829.93

* Calculated value

Table 2

Band	Small signal gain	$^{12}CO_2$	$^{13}CO_2$	$^{14}CO_2$
I	$\alpha_0(\%cm^{-1})$	1.07	0.64	0.55
II	$\alpha_0(\%cm^{-1})$	0.9	0.26	0.099
Measured	$\frac{\alpha_0 - I}{\alpha_0 - II}$	1.2	2.5	5.6

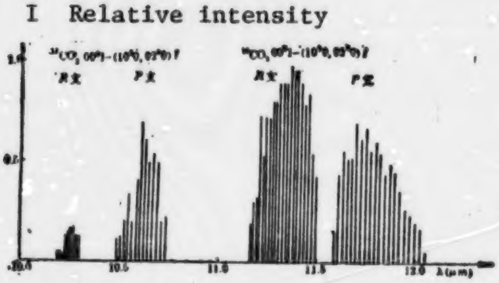

图2 $^{14}CO_2$-$^{12}CO_2$ 同位素激光器的谱线分布

Fig. 2 Spectral distribution of the $^{14}CO_2$-$^{12}CO_2$ isotope laser I = 8 mA, CO_2:N_2:He = 1:1:4.2, total gas pressure = 18.2 ± 0.2 Torr, $^{14}CO_2$:$^{12}CO_2$ = 60%:40%, gold plated reflection mirror R = 3m, 80 line/mm metal grating, λ = 11 μm.

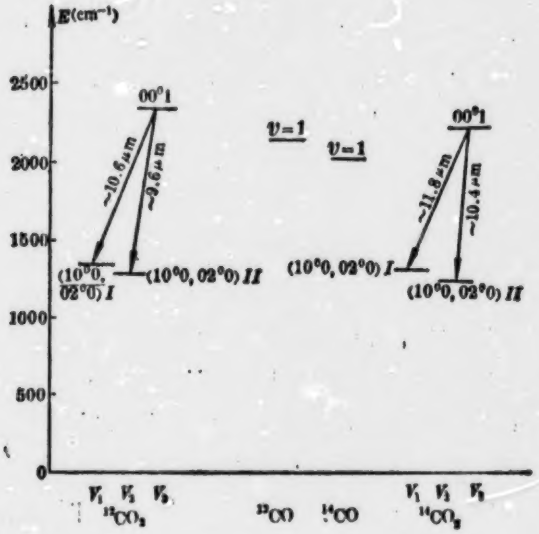
E(cm⁻¹)
2500
2000
1500
1000
500
0
00°1
~10.6μm
~9.6μm
(10°0, 02°0) I
(10°0, 02°0) II
v=1
v=1
00°1
~11.8μm
~10.4μm
(10°0, 02°0) I
(10°0, 02°0) II
V₁ V₂ V₃
¹²CO₂
¹²CO
¹⁴CO
V₁ V₂ V₃
¹⁴CO₂

Fig. 3 Vibrational Energy Levels of CO_2 Isotope

IV. Conclusion

We have developed a tunable $^{14}CO_2$-$^{12}CO_2$ isotope laser and extended the usual spectrum range of a $^{12}CO_2$ laser from 9-11 m to 9-12 μm.

The existence of the isotope competition effect allowed us to realize that the hybrid CO_2 isotope laser not only has a greater spectral output range than pure CO_2 isotope lasers but also saves the expensive $^{14}CO_2$ and $^{12}CO_2$ isotopes. More spectral lines may be obtained if a mixture of $^{14}CO_2$, $^{13}CO_2$, and $^{12}CO_2$ in an increasing proportion is used.

The authors thank Wu Yingju [0702 2503 5468], Lu Shanhua [0712 0810 5478], and Liang Mingqing [2733 2494 3237] for technical assistance.

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CSO: 8111/0461

AUTO-ALIGNMENT DEVELOPED FOR LARGE LASER SYSTEM

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 12 No 9, Sep 85 pp 543-546, 542

[Article by Wang Wucheng [3769 2745 2052], Wang Jianxiong [3769 0494 7160], Wu Hengxian [0702 1854 7359], Guo Ruoju [6753 5387 7467], Yang Jingxin [2799 6975 2450] and Hu Shiyuan [5170 1102 0337]: "Auto-Alignment of the Optical Path of a Larger Laser System"]

[Text] Abstract: A principle of optical path adjustment by servo-control mechanism is proposed. A computer program based on this principle has been successfully used in the auto-alignment of a laser system.

Introduction

A large laser system usually consists of an oscillator, a number of amplifiers and extensive optics. While in operation it is difficult to keep the laser beam from drifting. For example, the optical path of the pulsed solid state laser system used in nuclear fusion relies on an alignment control system so that the axial and angular drifts of the beams remain within a tolerable range. In this article we report our research results in this area.

Alignment-Control System

The alignment of the laser beam is carried out in sections. Each section uses a spatial filter as the alignment standard. The angle and axial position of the main beam upon entering the spatial filter are monitored by a transducer. The transducer consists of an aiming and an orienting optical image system and two corresponding quadrant tubes. They respond respectively to the axial drift and the angular drift of the beam. When the optical axis of the target beam deviates angularly from the optical axis of the transducer, the orientation quadrant tube of the transducer will become unbalanced and produce an orientation error signal. When the optical axis of the target beam is displaced laterally from that of the transducer, the aiming quadrant tube of the transducer will produce an aiming error signal. Based on the sign and magnitude of the error signals, the microcomputer connected to the quadrant tubes computes the angular and lateral deviation of the target beam and sends commands to the stepper motors of the two servo adjustment frames to move in the required direction by the proper number of motor steps.

The main components of the alignment control system are: two servo adjustment mechanisms with two degrees of controls for the azimuth and the pitch, a plane mirror that samples part of the target beam for the transducer, a transducer, an amplifier and a microcomputer. The layout is shown in Figure 1.

To analyze the operation of the alignment system, we consider a deviation of the optical path shown in Figure 2. The light spot positions of the aiming quadrant and the orientation quadrant of the transducer are shown in Figure 2(b). To restore the spots to their balanced positions on the quadrant tubes, the two servo mechanisms I and II should be adjusted so that the light beam AN_0 coincides with the original beam BO_0. Servo I should be rotated counter-clockwise to move point A toward point B. Servo II is then driven counter-clockwise so that the two beams coincide. In the adjustment process, when the servo I is rotated counter-clockwise to a certain angle, CA will become parallel to DB and AN_0 is then parallel to BO_0. This will balance the orientation quadrant tube, see Figure 3. Conservely, if servo I is rotated clockwise,

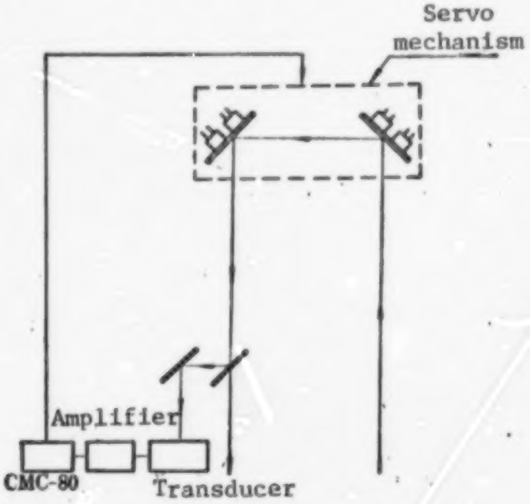

Fig. 1 Layout of the CMC-80 Auto-alignment System

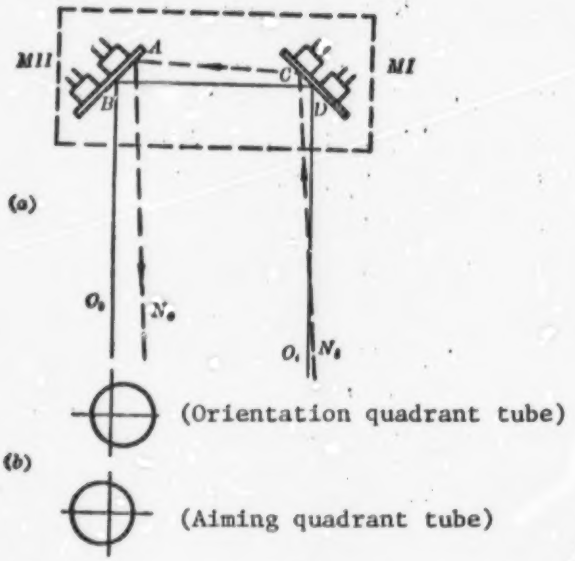
MII
A
B
C
D
MI
(a)
O_0
N_0
O_1
N_1
(b)
(Orientation quadrant tube)
(Aiming quadrant tube)

Fig. 2 Deviation of the Laser Beam

point A will increasingly deviate from point B and the orientation quadrant tube will become more and more unbalanced. The signal from the orientation quadrant tube can, therefore, be used in determining the proper rotation direction of the servo I mechanism. The angle of rotation is determined by the angular deviation of the beam upon entering servo I, that is, the angular drift of the system beam.

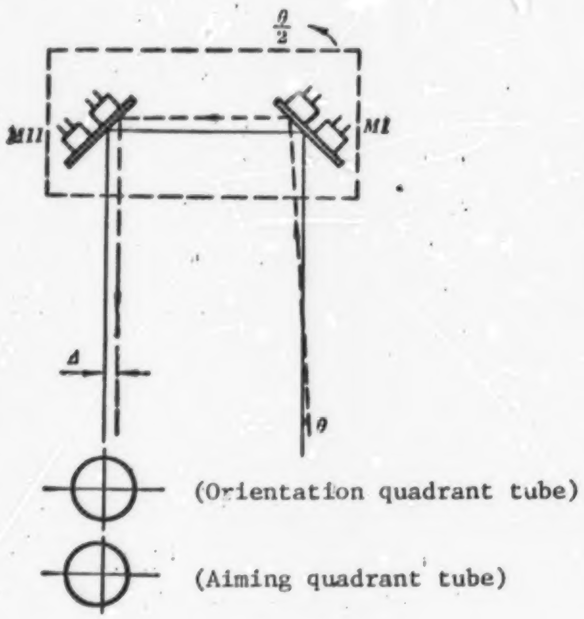
$\frac{\theta}{2}$
MII
MI
Δ
θ
(Orientation quadrant tube)
(Aiming quadrant tube)

Fig. 3 Beam Orientation After $\theta/2$ Adjustment by Servo I

For an angular deviation of θ, from the well-known law of reflection, servo I should be rotated in the counter-clockwise direction by an angle $\theta/2$ so that CA and AN_0 become respectively parallel to DB and BO_0, as shown in Figure 3. When the servo I is rotated an additional angle of $\varphi/2$ in the same direction, point A will be brought to coincide with point B. Figure 4 shows that $\varphi = \Delta/l$, where Δ is the axial deviation of the beam and l is the center-to-center distance of the mirrors of servo I and servo II. At this time the angle between the beam from servo II and the undeviated beam is also φ. Therefore, the beam will coincide with the original undeviated beam when servo II is rotated by an angle $\varphi/2$ in the same direction (counter-clockwise) as servo I. In other words, once the orientation motor rotation direction of servo I is determined and the angle is rotated to balance the orientation quadrant tube, the motor of servo II may be driven in the same direction until both quadrant tubes are balanced, see Figure 5. As can be seen, the rotational angles of servos I and II depend on the axial drift of the beam.

Based on the above, the servo adjustment concept may be summarized as follows:

(1) Determine the correct rotational direction of the stepper motor

The proper sense of rotation of servo I is determined by the indication of the orientation quadrant tube. If the trend is toward a balance after a certain number of steps, the rotation is in the right direction. Otherwise, the sense of rotation should be reversed.

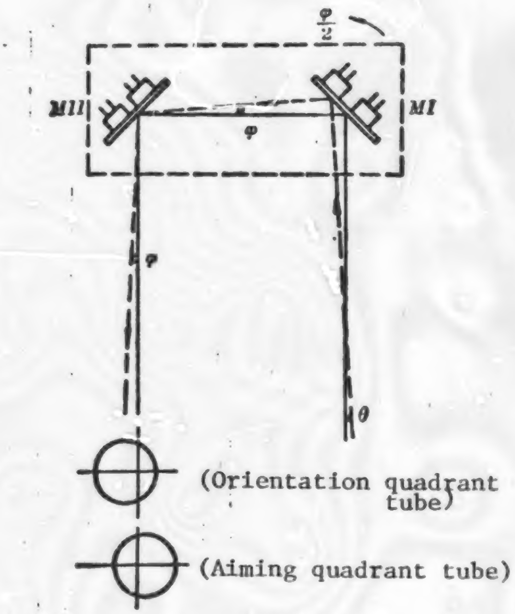

Fig. 4 Beam Orientation After Servo I Is Rotated by an Additional $\varphi/2$

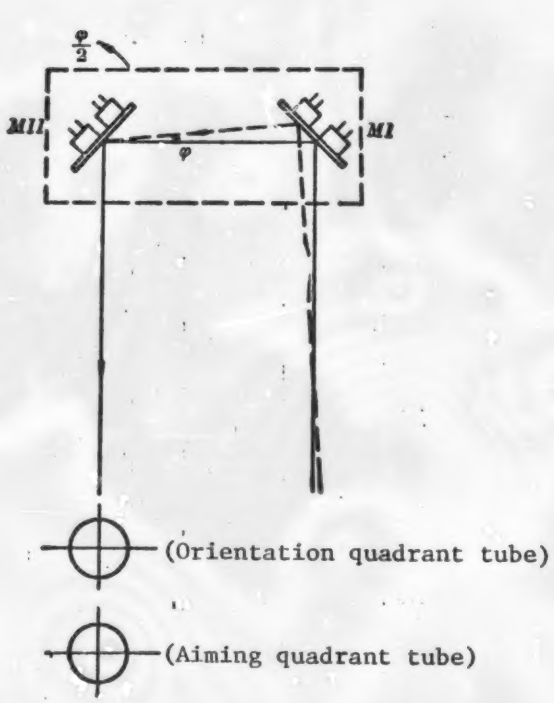

Fig. 5 Beam Orientation After Servo II Is Rotated by $\varphi/2$

(2) Determine the number of steps of the orientation stepper motor in servo I

Based on the direction of rotation determined above, the orientation motor of servo I is rotated until the orientation quadrant tube of the transducer is balanced. The number of steps depends solely on the angular drift of the beam.

(3) Aiming adjustment

Servos I and II are driven simultaneously in the direction determined earlier until the aiming quadrant and the orientation quadrant of the transducer are both balanced. The number of steps of the synchronized rotation of I and II depends on the axial drift of the beam.

At this point, the alignment is completed. The alignment of the pitch of the bream is similar to the alignment of the azimuth. If both have deviation, they may be corrected independently.

Computer Program

A CMC-80 computer is programmed to control the azimuth and the pitch tilt stepper motors of servos I and II. The flow diagram for azimuth-pitch control is given in Figure 6.

Experimental Results

A CW YAG laser is used as the light source in the auto-alignment experiment. The laser light is reflected from mirror M_o and enters servos I and II. The beam is then taken out by a beam splitter and fed into the transducer. The electrical signals from the aiming and the orientation quadrant tubes are amplified by two amplifiers and fed into the CMC-80 computer. The experimental setup is shown in Figure 7.

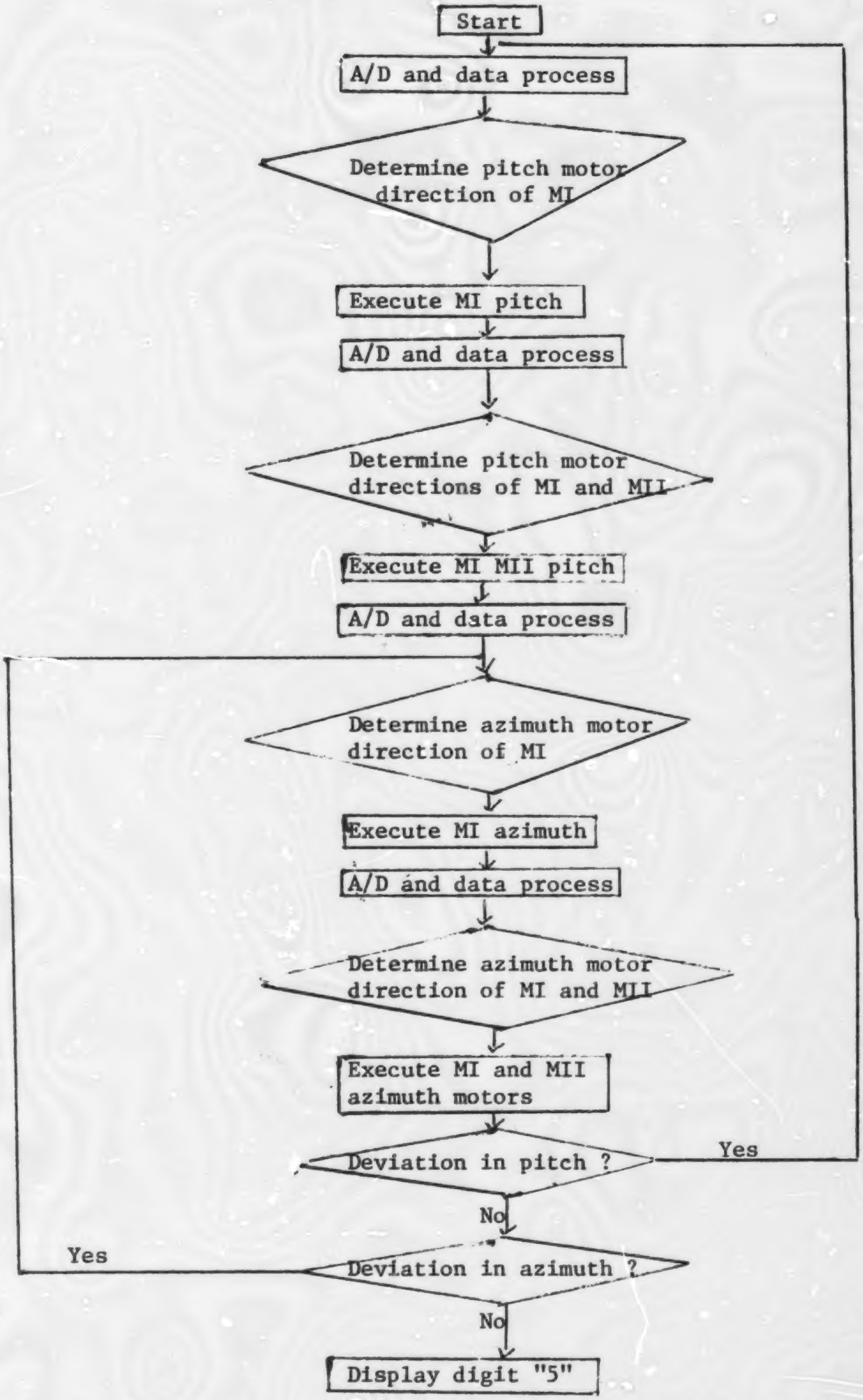
Start
A/D and data process
Determine pitch motor direction of MI
Execute MI pitch
A/D and data process
Determine pitch motor directions of MI and MII
Execute MI MII pitch
A/D and data process
Determine azimuth motor direction of MI
Execute MI azimuth
A/D and data process
Determine azimuth motor direction of MI and MII
Execute MI and MII azimuth motors
Deviation in pitch ?
Yes
No
Deviation in azimuth ?
Yes
No
Display digit "5"

Fig. 6. Flow diagram of pitch-azimuth control of the CMC-80 based auto-alignment system

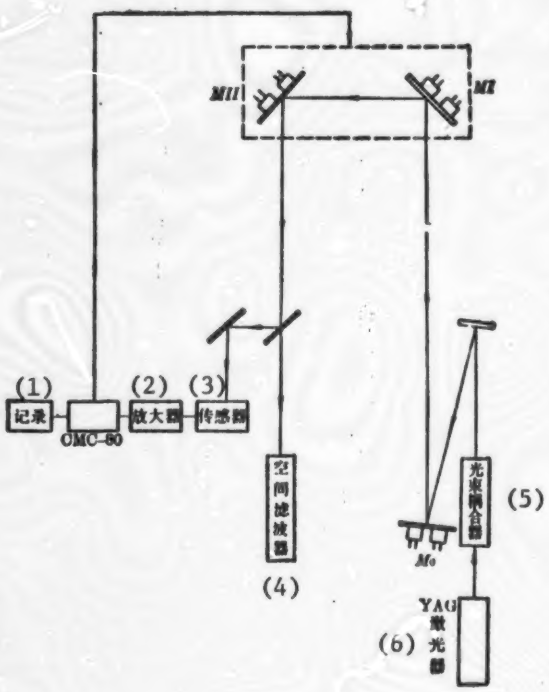

Fig. 7 Experimental layout of the CMC-80 based laser auto-alignment system

Key:

1. Recorder
2. Amplifier
3. Transducer
4. Spatial filter
5. Beam coupler
6. Laser

Experiments were performed for the following four beam deviation situations: (1) Beam deviation is simulated by advancing the azimuth and pitch motors of M_o 30 steps each; (2) azimuth and pitch motors of M_o move backward 30 steps each; (3) azimuth motor of M_o advanced 30 steps and pitch motor of M_o reversed 30 steps; (4) azimuth motor of M_o reversed 30 steps and pitch motor of M_o advanced 30 steps. Table 1 shows the values of the data converted into the decimal system.

Based on these experimental data, we computed the average accuracy of the auto-alignment system controlled by a CMC-80 computer. The accuracy of orientation is 1.8 percent and the accuracy in aiming is 1.4 percent. The corresponding angular drift is 0.5" and the axial drift is 102 μm of the main beam entering the spatial filter. In the experiment the temporal fluctuation of the laser power was eliminated with computer software.

Table 1. Data in decimal system

Deviation of laser beam		Aligned (original)				Deviated				Auto-aligned			
	Quadrant	1	2	3	4	1	2	3	4	1	2	3	4
Azimuth ↓ 30	orientation	53	52	51	54	30	46	35	19	44	44	46	42
Pitch ↓ 30	aim	56	57	59	62	72	55	41	52	59	58	60	59
Azimuth ↓ 30	orientation	31	30	32	31	22	22	35	32	35	36	32	35
Pitch ↓ 30	aim	43	41	42	41	32	33	48	64	39	39	40	40
Azimuth ↓ 30	orientation	35	37	39	36	17	24	39	24	31	31	30	31
Pitch ↓ 30	aim	45	48	46	43	35	30	43	51	45	45	46	46
Azimuth ↓ 30	orientation	25	27	24	31	25	26	20	19	26	37	26	26
Pitch ↓ 30	aim	43	44	41	45	51	47	34	35	44	42	41	43

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APPLIED SCIENCES

TIME-RESOLVED X-RAY SPECTRA STUDIED

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 12 No 9, Sep 85 pp 570-572

[Article by Pan Chengming [3382 2052 2494], Yin Guangyu [3009 0342 5940], Zhao Shicheng [6392 0013 6134], and Zhu Daqing [2612 1129 1987]: "Calibration of X-Ray Streak Camera"]

[Text] Abstract: The interaction of laser light with plasma is described which offers X-rays directly or indirectly. The specifications as well as the calibration of the X-ray streak camera are presented. Its physical application in laser produced plasma is indicated.

X-ray emitted by the laser plasma plays a direct or indirect role in the interaction of laser and plasma. The characteristic length is several micrometers to several hundred micrometers and the characteristic time is several picoseconds to several hundred picoseconds. A device for diagnosing the time resolved X-ray must therefore have a time resolution of several picoseconds to several hundred picoseconds. An -ray streak camera is designed for this specific purpose.

Before an X-ray streak camera is put in use, it must be calibrated for time resolution, dynamic range, scanning linearity, and trigger jittering. Its intensity and linear output range must be quantified together with its spectral resolution devices such as reflecting mirrors and filters.

1. Calibration of Time Resolution

The time resolution of an X-ray streak camera is defined as full width at half maximum (FWHM) of the received signal of the δ X input. Physically the measurement is done by using a short X-ray pulse on the cathode of the streak camera and the FWHM value is then read off the temporal change of the pulse intensity shown on a temporal analyzer.

If the resolution time of the streak camera is T_{xc} and the pulse width of the incident X-ray is T_{xi}, then the pulse width of the camera output is given by

$$T_0=(T_{xc}^2+T_{xi}^2)^{1/2} \qquad (6)$$

Here we assume that the pulse has a Gaussian distribution. Therefore, knowing T_{xi}, one may obtain T_{xc} by measuring T_o. A high power laser hitting a metallic target (e.g. Fe, Cu, Al) serves as a source for short X-ray pulse. The apparatus is shown schematically in Figure 1.

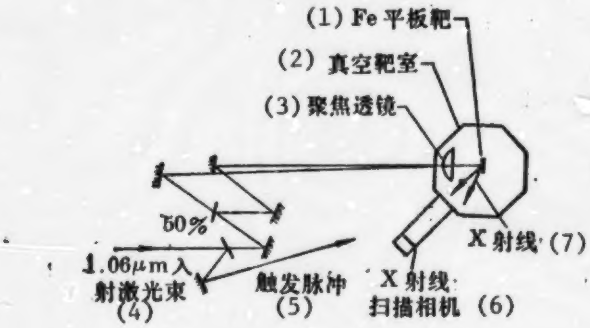

Fig. 1 Calibration Apparatus for the Time Resolution of X-ray Streak Camera

Key:

1. Planar Fe target
2. Vacuum target chamber
3. Focusing lens
4. 1.06 μm incident laser beam
5. Trigger pulse
6. X-ray streak camera
7. X-ray

2. Calibration of Dynamic Range

In 1976 W. Friedman first proposed the concept of the time resolution and intensity correlation of an X-ray streak camera. The basic idea is that the output pulse width may be increased by increasing the intensity of the incident light pulse of a constant pulse width. The dynamic range is defined as the change of the incident light pulse intensity when the output pulse width is increased by 20 percent when the incident pulse width (FWHM) is held constant, see Figure 2. When a film is used as the element for recording the output light pulse, the lower bound of the dynamic range is the fog of the film. When an optical multichannel analyzer (OMA) is used, the lower bound of the dynamic range is the noise level of the OMA. If the stream camera has sufficient gain, a single photoelectron will produce a signal much greater than the noise. In this case, the definition above is meaningless. For a practical dynamic range, the lower bound may be considered as the minimum level measurable by the streak camera.

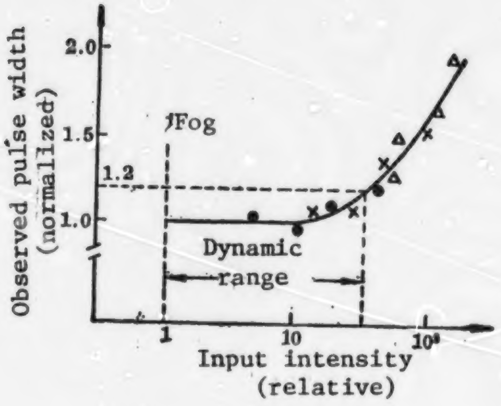

Fig. 2 Dynamic Range of an X-ray Streak Camera

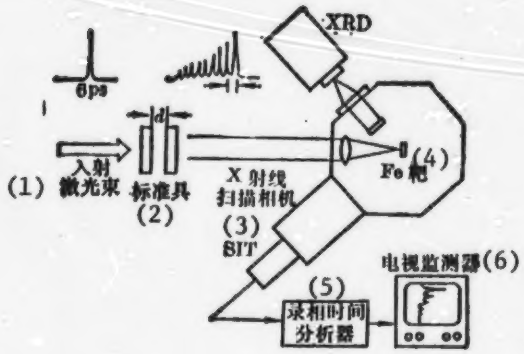
6ps
d
XRD
(1) 入射激光束
标准具 (2)
X 射线扫描相机 (3)
SIT
Fe 靶 (4)
(5) 录相时间分析器
电视监测器(6)

Fig. 3 Calibration Setup for the Dynamic Range of an X-ray Streak Camera

Key:

1. Incident laser beam
2. Etalon
3. X-ray streak camera
4. Fe target
5. Recording time analyzer
6. Television monitor

The calibration setup for the dynamic range of the streak camera is shown in Figure 3. A single picosecond pulse enters an etalon made of two reflecting mirrors and produces a pulse sequence with a constant time interval and decay rate.

If the separation of the two mirrors in the etalon is d, then the separation between two adjacent pulses is

$$\Delta t = 2d/c \qquad (2)$$

When the pulse sequence is used in the irradiation of metallic targets such as Cu, Al, and Fe with an X-ray conversion efficiency of ε, the X-ray intensity produced by the mth pulse is $I_{mx} = I_1(R_1R_2)^{m-1}\varepsilon$, and the X-ray intensity converted from a light pulse of intensity I_1 is $I_{1x} = T_1T_2I_0\varepsilon$. Here R_1, R_2, T_1 and T_2 are respectively the reflectivity and transmissivity of the two mirrors of the etalon. If the conversion efficiency is different from different intensity, we assume the conversion efficiencies to be ε_1, ε_2, ..., ε_m for the m pulses. Then the X-ray intensity generated by the mth laser pulse is $I_{mx} = I_1(R_1 \cdot R_2)^{m-1} \cdot \varepsilon_m$, and the X-ray intensity produced by the laser pulse of intensity I_1 is

$$I_{1x} = T_1 \cdot T_2 \cdot I_0 \cdot \varepsilon_1$$

In the calibration the X-ray intensity is measured with an XRD detector.

The dynamic range is limited mainly by the space charge effect in the phaser tube.

3. Intensity Calibration

The intensity calibration apparatus of the X-ray streak camera is shown in Figure 4. The XRD detector and the streak camera (including the reflection mirror, the filter and the spectral resolution system) are at an angle of 45° with respect to the laser axis.

The X-ray intensity I_a on the receiving system (film or CCD recorder) is

$$I_a = \frac{I_i d C_q T C_f \varepsilon}{m_x m_t U_c} \qquad (3)$$

where I_i is the incident X-ray flux, d is the slit width, C_q is the conversion efficiency of the photocathode, T is the electron transmissivity of the phaser tube, C_f is the electro-optic fluorescence efficiency, m_x is the spatial magnification of the image, m_t is the temporal magnification of the image, U_c is the image output speed change, and ε is the efficiency of the detector (film or CCD detector). In Eq.(3), only C_q depends on the X-ray energy and all the other parameters depend only on the construction of the streak camera and physical constants. Equation (3) can therefore be written as

$$I_a = A C_q I_i \qquad (4)$$

where A is a constant depending on all other components of the camera except the photocathode. The calibration procedure determines the value of A, that is,

$$A = \frac{I_a}{C_q I_i} \qquad (5)$$

C_q is determined independently using the method of Ref. 1. I_i is the incident X-ray flux and is measured with an XRD.

The calibration procedure for the linear output range of the X-ray streak camera is similar to above. By varying the laser intensity and hence the incident X-ray flux I_i, the linear range where A varies with I_i linearly is found.

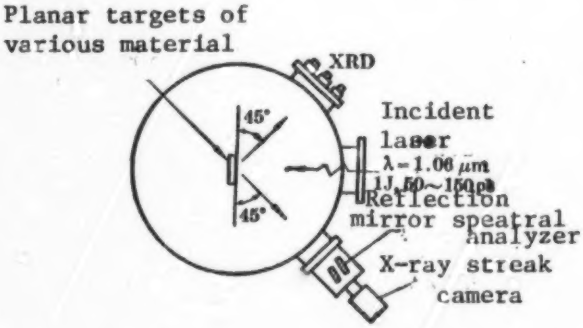

Fig. 4. Intensity Calibration Apparatus of the X-ray Streak Camera

4. Nonlinearity, Trigger Delay and Jitter

Nonlinearity of the scanning velocity not only shows up in the time axis but also affects the intensity. This is because any compression of the time axis due to nonlinearity will increase the intensity even if the pulse intensity fed into the system is held constant. To calibrate the linearity, the setup of Figure 3 may be used. The etalon is used to generate a sequence of laser pulses equally separated in time to bombard a target. The separation between the X-ray pulses produced by the laser plasma is identical to the separation of the laser pulses. The distance between the X-ray pulses is $\Delta X = m \pm \Delta m$ and the corresponding time interval is Δt. The scanning velocity v is therefore $\Delta X / \Delta t$ and the nonlinearity of the scan is $\Delta m/m$.

In order for the streak camera to form an image at the center of the screen, the trigger signal must arrive before the X-ray signal reaches the slit on the camera. This can be accomplished by suitably delaying the time using fiber optics or cable.

In single measurements using the streak camera, trigger jitter does not affect the measured value. For small signal X-ray pulses, multiple exposure and averaging are required. Time jitter of the trigger causes jumps of the image on the screen and measurement errors. If the FWHM value of the trigger jitter T_t obeys a Gaussian distribution, then

$$T=(T_t^2+T_x^2+T_r^2)^{1/2} \qquad (6)$$

where T_x is the width of the incident X-ray pulse, T_r is the time resolution of the camera, and T is the FWHM value of the integrated incident X-ray signal.

The trigger jitter is therefore

$$T_t=(T^2-T_x^2-T_r^2)^{1/2} \qquad (7)$$

If the jitter is less than the time resolution, it may be ignored. Trigger jitters may be compensated using computer software.

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/8309
CSO: 8111/0461

32W OUTPUT FROM Cu-VAPOR LASER OBTAINED

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 12 No 9, Sep 85 p 550

[Text] Cu vapor laser is a self-terminating transition, high gain gas discharge laser. It is capable of high power and high efficiency operation. It emits a visible green line (510.6 nm) and a visible yellow line (578.2 nm). The Shanghai Institute of Optics and Fine Mechanics began its research of Cu-vapor laser in 1983 and has achieved 10W, 15W and 23W operation at 6-10 kHz using a ϕ 23x1000 mm discharge element. The operation time exceeded 200 hours. Using a ϕ 35x1000 mm discharge element and a 6 kHz repetition rate, an average output power of 26.5W was obtained last year. Recently, after improving the excitation source and other working parameters, the unit delivered 32W of output power. The laser beam diameter was 35 mm, the divergence angle was 5 mrad, the pulse width was 30 ns, the buffer gas used was neon and the lasing efficiency was 0.45 percent. [Shanghai Institute of Optics and Fine Mechanics]

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CSO: 8111/0461

BRIEFS

COMPACT, SELF-HEATED $CuCl_2$ LASER--The Nanjing Engineering College has successfully developed a compact, sealed, self-heated $CuCl_2$ laser. The discharge length of the laser is 38.5 cm, the inner diameter is 0.9 cm, the output power is about 800 mW, the power stability is 2 percent, and the service life is 300 hours. The laser has unique structural design and was produced with a special technique. The discharge tube is of the concave trough type and a magnetic field is applied at the window to reduce the window contamination by the copper vapor. The working material was also specially processed. This achievement of the Nanjing Engineering College was certified in a meeting held by the Jiangsu Provincial Scientific Committee and the laser is being mass produced by the Shanghai Yaming Lightbulb Plant. [Text] [Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 12, No 12, 20 Dec 85 p 751] 9698/6091

COMPACT TEA CO_2 LASER--The Nanjing Engineering College has developed a compact TEA CO_2 laser. The external dimensions are 76 mm diameter by 240 mm, comparable to that of a regular He-Ne laser. The case is machined from a lithium mica microcrystalline glass. The energy per pulse is 100 mJ. The average output energy remains above 60 mJ after 10^6 pulses at a repetition rate of 1 Hz. The pulse width is 40-50 ns, the peak power is greater than 1 MW, and the output stability is 2 percent. Researchers at the Nanjing Engineering College developed this laser with several new technologies. First, they developed a compact, sealed preionization electrode and obtained a strong and uniform glow discharge in a very small volume. Second, they introduced some CO and H_2 gas into the working medium and obtained the optimum mixture ratio. Third, they placed a diaphragm in the resonance cavity to prevent contamination of the reflection mirror. This research result obtained by the Nanjing Engineering College has passed the certification in a meeting held by the Jiangsu Provincial Scientific Committee on 26 June. The Nanjing Electron Tube Plant will produce and market the compact TEA CO_2 laser. [Text] [Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 12, No 12, 20 Dec 85 p 751] 9698/6091

CSO: 4008/34

STUDIES OF TRINITROMETHYLATION REACTIONS (II) THE SYNTHESIS OF NONANITROMESITYLENE AND RELATED COMPOUNDS

Beijing BINGGONG XUEBAO [ACTA ARMAMENTARII] in Chinese No 4, Nov 85 pp 1-8

[English abstract of article by Zhou Faqi [0719 4099 1477] and Fan Nengting [2868 5174 1694]]

[Text] Utilizing the trinitromethylation reaction, nonanitromesitylene is synthesized from s-benzene-tricarboxaldehydoxime via hexanitromesitylene and its trispotassium salts, using nitrogen tetraoxide as the nitration reagent. The products related to the synthesis of nonanitromesitylene are described in this paper, namely 3,5-bis(trinitromethyl)benzaldehyde, 5-trinitromethyl-1,3-phthalaldehyde, 3,5-bis(dinitromethyl)benzaldehyde and its bispotassium salt, 5-dinitromethyl 1,3-phthalaldehyde and its potassium salt, m-trinitromethyl benzaldehyde, m-dinitromethyl benzaldehyde and its potassium salt.

STUDIES OF THE CATALYTIC ACTION OF LEAD SALICYLATE ON THE THERMAL DECOMPOSITION OF HMX USING TIME-OF-FLIGHT MASS SPECTROMETER

Beijing BINGGONG XUEBAO [ACTA ARMAMENTARII] in Chinese No 4, Nov 85 pp 9-16

[English abstract of article by Jing Zhongxing [2529 0022 5281] and Bai Mulan [4101 2606 5695]]

[Text] Time-of-flight mass spectrometer has been used to study the effects of lead salicylate as a catalyst for the thermal decomposition of HMX at a temperature range of 150°C to 300°C. Its effects on the dissociated gaseous products and decomposition rate of HMX are determined and the kinetic parameters of thermal decomposition calculated. The catalytic activity of lead salicylate is studied and the mechanism of the catalytic action of lead salicylate is discussed in the paper.

Explosives Technology

NUMERICAL METHODS FOR SIMULATING SHAPE FORMATION IN SELF-FORGING-FRAGMENTS

Beijing BINGGONG XUEBAO [ACTA ARMAMENTARII] in Chinese No 4, Nov 85 pp 25-32

[English abstract of article by He Gaoyu [0149 7559 3768], He Shunlu [0149 7311 6922] and Li Luyin [2621 6922 5593]]

[Text] In this paper two-dimensional numerical methods for simulating shape formation of self-forging-fragments are studied. The dynamic equations are based on a perfectly-elastic, ideally plastic-fluid model. The emphasis is placed on the processing techniques of different calculating methods, such as artificial viscosity, calculation of the sliding surface and regionalization (re-netting). A numerical example for the shape formation process of the self-forging-fragment is given and compared with experimental X-ray photos, showing good agreement between them.

Laser Technology

OPTIMIZATION OF INFORMATION PROCESSING METHODS IN LASER RANGEFINDING

Beijing BINGGONG XUEBAO [ACTA ARMAMENTARII] in Chinese No 4, Nov 85 pp 33-38

[English abstract of article by Tao Huacheng [7118 0553 2052] and Lu Ming [7120 2494]]

[Text] In laser rangefinding for an A/A artillery system, the two salient problems to be confronted presumably are: (1) how can the range be predicted if the radiated laser beam has no return waves? and (2) at the initial phase, how many times in succession should the return wave be received before the director can start working? In this paper, several methods are proposed as reasonable solutions. Quantitative calculations and analysis of these methods through computer simulation are given and the results are listed in the appendix.

9717
CSO: 4009/40

Motion Detection

CORRELATIVE MOTION DETECTION BY VISUAL SYSTEM

Beijing BINGGONG XUEBAO [ACTA ARMAMENTARII] in Chinese No 4, Nov 85 pp 17-24

[English abstract of article by Zhang Shaowu [1728 1421 0710], Wang Xiang [3769 5046] and Sun Qijian [1327 0366 1017]]

[Text] Motion detection plays an important role in visual systems. Based on Reichardt's model of motion detection for insects, an engineering model of motion detectors with multiple-channels is proposed in this article. This model is capable of detecting direction and transverse angular velocity in a wide available range in real time. Not only can it detect the motion of a pattern with a discriminatable outline and edge, but it can also detect the motion of a texture pattern without a discriminatable outline and edge.

The parameters of the model are suggested as follows:
1. The time constant τ_L of the low-pass filter of the first order influences the available range of velocity detection. It depends on the space d between two receivers of the motion detector--delay time t_a corresponding to the superior limit of detectable velocity and delay time t_b corresponding to the inferior limit of detectable velocity as well as the degree of precision required in velocity detection.
2. The ratio of the time constant high-pass filter τ_H to the loss-pass filter τ_L also influences the available range of velocity detection. The smaller the time constant L_H is, the greater the superior limit of detectable velocity will be.
3. The correlator sampling time T is determined as follows:

$$T \geq \frac{1}{2\epsilon^2} \times [\tau_L + 2t_a + 2]$$

4. The available range of velocity detection by motion detectors having multiple-channels consisting of N channels is enlarged to $\frac{d_o}{t_b} \times (\frac{t_a}{t_b})^N$. The space d between the two receivers of the motion detector in the kth channel can be determined as follows:

$$d_k = d_o \times (\frac{t_a}{t_b})^k, \; k = 0, 1, \ldots, N.$$

INVESTIGATION OF FLOW-INDUCED VIBRATION FOR HEAT EXCHANGER SIMULATOR IN NUCLEAR REACTOR

Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 5 No 4, Dec 85 pp 294-305

[English abstract of article by Hang Zilong [5592 5261 7893], Zhao Soujun [6392 1344 6874] and Li Haibao [2621 3189 1405], et al., of Southwest Institute of Nuclear Reactor Engineering]

[Text] The experimental and analytical results of flow-induced vibrations for a simulator heatexchanger in a nuclear reactor are presented. The tests were carried out in a water loop used for studying flow-induced vibrations for the reactor structure and components. The simulator is about 4 meters long and has a rectangular cross-section with 35 heatexchange tubes.

Both the amplitudes and strains of the tubes in axial flow and cross flow regions are measured. The maximum values of amplitude and strain of the tubes as a function of the velocity and length of the tube-span are given. The results of the measurements are compared with the calculated values.

THERMAL SHOCK STRESS MEASUREMENTS OF FAST NEUTRON PULSE REACTOR

Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 5 No 4, Dec 85 pp 306-314, 355

[English abstract of article by Jin Zhanglin [6855 7022 2651] of Southwest Institute of Nuclear Physics and Chemistry]

[Text] In this paper a method for the measurement of surface stress distribution of a fast neutron pulse reactor during a blasting pulse is presented. The weakest points with maximum stress concentration factors were found and monitored in operation. A stress vs lower fission yield curve was made, then extrapolated to the next higher yield point until the maximum allowable stress was reached. In this way the maximum pulse yield was safely obtained.

Nuclear Science

REACTOR CORE THERMAL-HYDRAULIC DESIGN OF QINSHAN NUCLEAR POWER PLANT

Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 5 No 4, Dec 85 pp 315-323

[English abstract of article by Chen Yuxiang [7115 3022 3276] and Zhou Quanfu [0719 0356 4395] of Research and Design Institute No 728]

[Text] The PWR core thermal-hydraulic design, including the design objective, criteria and main design parameters, for the Qinshan Nuclear Power Plant is described. In addition, thermal-hydraulic tests related to the design are also discussed briefly.

Emphasis is placed on the modified single-channel model design method. Some important analytical results using the PWR core fuel rod thermal characteristics analysis program are also given.

STUDY OF THE SOLIDIFICATION OF SPENT TRIBUTYLPHOSPHATE SOLVENTS

Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 5 No 4, Dec 85 pp 332-337

[English abstract of article by Luo Shanggeng [5012 0006 1649] of the Institute of Atomic Energy, Beijing; and S. Drobnik of KFK, West Germany

[Text] The processing conditions for solidification of spent TBP-solvents and its product characteristics are described in this paper. The resistance to leach and radiation and the thermostability and durability of storage of products made from simulated and real TBP-solvents are measured. The loadage of the solidification product is as high as 70 wt percent. The analysis indicates that the solidification products meet the requirements for storage and final disposal.

9717
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END

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19 March 1986

China Report

SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

MICROELECTRONIC TECHNOLOGY TO IMPROVE INSTRUMENTATION

Shanghai ZIDONGHUA YIBIAO [PROCESS AUTOMATION INSTRUMENTATION] in Chinese
20 Sep 84 p 6

[Article by Wei Yangan [5898 7122 1344] Wuhan Institute of Instruments and Meters]

[Text] The instrumentation devices industry will accelerate automation technology; only in striving for improvement in quality can we actually fulfill the new products requirements of the national economy, and guarantee improvement of existing products. Danfoss of Denmark makes cryogenic self-regulating devices which are basically identical or almost identical in structure to those produced in China. But there is a big difference in reliability of their products as compared to ours. For example, the operating life of the switches used in Chinese pressure and temperature controllers is about 20,000 operations as compared to 400,000 for similar Danfoss products, and actually the specification requirement is for 1 million. The reason that Danfoss products can reach this level hinges on many guaranteed conditions. Two are worthy of our scrutiny: One, the advanced level of its parts machining technology--the principal work processes mostly utilize automatic control or computer control, thereby assuring that parts meet machining precision and functional requirements. The other, Danfoss has more complete testing procedures and equipment to assure product quality. The specialized testing equipment is all designed and developed in-house, some even have computer connections, and these specialized pieces of equipment are very suitable for control of the production processes. In this respect, they are willing to invest and put forth effort, and, as a result, their products have earned consumer confidence in the international market. For many years, their cryogenic self-regulating instrumentation devices have kept about 40 percent of the total sales volume in the international market.

In light of this situation, our instrumentation device enterprises should not only quickly introduce microelectronic technology into their own products but should also guide this technology in progress in its own field. This is to improve technological quality and level of our enterprises help us do our best to coordinate the development of products, technology, and microelectronics and to basically narrow the gaps, in the same fields, between our country and others.

12744/8309
CSO: 4008/232

CONTENT OF REPORT ON PROVINCIAL S&T SITUATION

Kunming YUNNAN RIBAO in Chinese 12 Oct 85 p 2

[Text] On the morning of 8 October Huang Aoluo [1728 2407 5012], director of the provincial science and technology [S&T] system, gave a "Report on the Situation Regarding Restructuring of the Science and Technology System in This Province" at the 17th Session of the Standing Committee of the 6th Provincial People's Congress. An abstract follows:

The "Report" spoke of the situation for progress and development in the restructuring of the science and technology system. The "Report" said that after the proclamation of the "Resolution by the CPC Central Committee Regarding the Restructuring of the Science and Technology System," the provincial government held an all province science and technology working conference in the latter part of May, which made up a full scale plan for the restructuring of the science and technology system. At that time, the primary things taken up were as follows: 1) organize the cadre to study the "Resolution," pass on the spirit of the all province science and technology working conference, and unite all areas and units into actual study and drafting of a restructured system and program; 2) the majority of research institutes carried out some reforms of varying degrees, which stimulated the integration of research with production, and which was a positive factor in industrial and agricultural production, especially for advances in small and medium enterprise technology. At the same time, ten research institutes have already begun to be self sufficient through service fees; 3) technical service of all sorts has developed vigorously, and the technology markets are quite lively. 4) A number of research, teaching, and production units have set up more than 30 research-production joint organizations, which have increased the development capacity of enterprise technology.

The "Report" stressed short-term arrangements for the restructuring of the science and technology system of this province, chief among which are:

1. Reforming the funds allocation system to gradually change the situation whereby the state is too encompassing and controls too tightly. Changing the funds management methods for the 130 independent research institutes throughout the province that differ in conditions. Thirty-one technology development institutes among them have gradually eliminated service fees. Considering that the majority of the institutes in our province are basically

weak, it has been decided that of the service fees reduced in allocation during the seventh 5-Year Plan, one-half would be returned to the original unit, and one-half would be put into various levels of science and technology development funds to be used for science and technology service. For 28 social welfare or technical service research institutes, the state will continue to allocate service fees, there will be an outlay responsibility system, and at the same time they will actively organize income accumulation funds. For 71 agriculture, forestry, animal husbandry, by-products, and fishery sciences institutes, the state will provide service fees, and they will implement an outlay responsibility system to encourage them to actively organize an autonomous income. Six institutes among them will become free of service fees, and the majority or totality of the service fees that are reduced in allocation for them will be returned to the original units to be used in improving the conditions for agriculture science research.

To invigorate scientific research and further enhance and develop scientific and technical service, research funds in this province during the seventh 5-Year Plan ought to be not less than the average rate of growth during the sixth 5-Year Plan, increasing annually. Beginning next year, capital construction funds for research units will be provided in portions. Step by step and in a planned way, a group of major research institutes will be outfitted to help build up a number of local, prefectural, and municipal level technology markets. The province is also prepared to allocate a technology exploitation fund to act as a compensation discount for supporting major technology exploitation projects. Credit plans of all levels ought to arrange guidelines for science and technology loans to support scientific and technical service.

2. Expedite the restructuring of scientific research institutes. Faced with the fact that the restructuring of the research institutes in this province will develop unevenly, and the situation that some policies are not clear or are not implemented, the provincial government will issue "Temporary Provisions Regarding Some Problems in the Restructuring of Scientific Research Institutes" to promote more development in institute restructuring. During the seventh 5-Year Plan, the province is prepared to help 17 province affiliated technology exploitation research institutes establish testing workshops, and the province will work with prefectures and autonomous prefectures to help affiliated agricultural research units establish bases for experimentation and demonstration. To develop the products that are an advantage to this province, we will first of all set up the Liangyan Research and Development Center to create research and development centers or bases by stages and groups for dominant resources like spices, medicinal materials, flowers and plants, subtropical fruits, and winter and spring early vegetables. At the same time, they will study scientific and technical development strategies for Yunnan that will gradually form reasonable basic research, applications research, and technical development research organizations with Yunnan characteristics.

3. Vigorously exploit technology markets. In addition to large scale comprehensive technology fairs held at regular intervals, we will establish a group of technology exchanges and development organizations. First of all, we will take care of the ten permanent technology markets that have already begun

operation, and we will clear up and reorganize the various civilian science and technology companies (centers) to genuinely serve economic construction. We will provide support in the aspects of funding, loans, and tax revenue for technology transactions and technology development projects.

4. Enhance enterprise capacity for the absorption and development of technology. Capacities for the absorption and development of technology by enterprises in this province are weak, so we must restructure the current enterprise science and technology system to achieve the three implementations of tasking, organization, and outlay. Large and medium scale enterprises should strengthen their departments of technology development and establish their own research institutes (laboratories); small enterprises should join together to set up technology development organizations, or establish various forms of joint organizations with scientific research or educational units, all of this to strengthen enterprise capacities for technology absorption and development. Enterprise science and technology should serve the remolding of traditional technology, the overcoming of technical difficulties, the broadening of technical achievements, the development of new products, and the seeking of superiority, a recognized name, and foreign currency, and should also organize technology education and technology training and improve the quality of their staffs. They should select more mature yet valuable "short, even, fast" technical projects, concentrate energies, stress breakthroughs, and drive on advances in town and township enterprise technology.

5. Gradually restructure the agricultural science and technology system. The current agriculture and technology system is not reasonable, it is fractured, dispersed, and to a great degree restricts the development of current capacities. To suit adjustments to agricultural production structures and the requirements of agricultural specialization, commercialization, and modernization, the agricultural science and technology system is undergoing reform. Based on natural conditions in Yunnan and the laws of the development of science and technology, it must gradually come to be a system with various points of focus and all kinds of characteristics, that will coordinate the developed provincial, prefectural, and county hierarchical agricultural scientific research and dissemination. Agricultural science and technology must put the science and technology of foodstuff production at the forefront, and cannot be lax in doing so. It must enthusiastically expand its horizons, and develop toward fitting the industries of agriculture, forestry, animal husbandry, by-products, and fishing with production, supply, sales, storage, shipping, and processing. And also, on the basis of experiments and demonstrations of mountain region development, to place mountain region development among the important items on the agenda, strengthen leadership, make reasonable arrangements, study and formulate development plans, and by relying on the broad mass of scientists, technicians, cadre, and the public, to put a new face on the comprehensive development of the mountain regions.

6. Fully develop the roles of current talent, and enthusiastically train various kinds of specialist talent. Implement a management system for scientists and technicians that integrates planned deployment with a hiring system. On an experimental basis, gradually expand the scope of the hiring system. We must maintain reasonable transfers of talent, must combine projects of technology development and economic cooperation, must adopt

various channels and modes, must develop intellectual support and intellectual movement, and must organize scientists and technicians who are in the field from central areas to make contributions to the economic construction of Yunnan. We will better implement the policy toward intellectuals, and will be concerned about them politically, vocationally, and in their living environment. We will integrate the characteristics of the intellectuals, will develop education regarding communist ideals and professional ethics, and will do well at building spiritual civilization. We will base ourselves upon training the various specialist talents in the province and at the local level, and will especially enhance the cultivation of specialist talent at the borders and in the mountainous regions. We have decided in the province that each year we will send a group of young and middle aged scientists, technicians, and teachers to study abroad and for advanced training.

7. As science and technology develops, science and technology legislation becomes more urgent. Based on arrangements by the national people's congress, scientific and technical circles and legal circles must make a concerted effort to study and propose local laws and regulations in the fields of science and technology to ensure the development of science and technology in this province.

Finally, the "Report" stressed that to strengthen the scientific and technical line and carry out a full scale restructuring of the science and technology system would be a major event in the whole picture of the modernization of Yunnan. All levels of leadership must take the lead in studying the "Resolution," in further improving understanding, in clarifying the goals, direction, focus, and policies of the restructuring of the science and technology system, in conscientiously augmenting leadership, and in carrying scientific and technical service in this province forward to a new stage of development.

12586
CSO: 4008/2027

PROVISIONS TO TIGHTEN S&T APPRAISAL SYSTEM DETAILED

Tianjin JISHU SHICHANGBAO [TECHNOLOGY MARKET WEEKLY] in Chinese 15 Oct 85 p 1

[Text] To enhance the management of scientific and technical achievements, and to put a stop to formalism in the appraisal of scientific and technical achievements, the State Science and Technology Commission and the State Economic Commission have jointly issued "A Circular Regarding Enhancing the Management of Scientific and Technical Achievements," subject to approval by the State Council. It was pointed out in the communication that the technical appraisal of scientific and technical achievements (including developmental achievements by enterprises with new products and new techniques) is an important link in science and technology. For some years now, many regions and departments have diligently implemented management rules for scientific and technical achievements, strictly carrying out the appraisal of scientific and technical achievements, which has stimulated the exchange, application, and dissemination of scientific and technical achievements. This has had a positive effect on stimulating progress in science and technology and for the development of economic construction. However, because the system has not been sufficiently perfected, there are too many scientific and technical appraisal conferences of all kinds. Whether an achievement is large or small, an appraisal conference is held for it, which happens throughout the country no less than hundreds of thousands of times each year. Many appraisal conferences are merely formalistic, which costs the workers financially, and some of the conferences have been changed from serious appraisal conferences to product marketing conferences. In carrying out appraisal of achievements, some units treat their guests royally and present gifts, take them on trips, and lower the appraisal standards at will, even to the extent that some immature scientific and technical achievements have entered society to the loss of the state, groups, and individuals. Therefore, the "Circular" has made five specific provisions.

1. That each area and each department must strengthen its leadership in managing scientific and technical achievements, must diligently carry out the "Provisional Regulations for the Technical Appraisal of New Products and New Techniques" passed by the State Council in 1961 and the "Provisions Regarding the Management of the Achievements of Scientific and Technical Research," passed in 1984 by the State Science and Technology Commission, scientific and technical achievements must be strictly appraised according to standards, and the level of scientific and technical achievements must be ensured.

2. That for the evaluation and appraisal of scientific and technical achievements, evaluation may be carried out differently under different conditions. Anything falling under the following conditions may be regarded as the conclusions of appraisal, for which another appraisal conference need not be held: (1) when based on the research tasking letter or contract there has been technical checking and testing for approval by the relevant specialist department given the task, and when certification has been issued; (2) when technical maturity has been demonstrated in actual production practice, when it is economically reasonable, when there has been a technical evaluation, when inspection by the relevant specialist department is up to standard, and when certification has been issued; (3) when inventions and creations have been issued patents by the China Patent Office, and after implementation have achieved economic results; (4) if the achievements of scientific theory have already been read before a national (or international) scholastic conference, or have been published in a national (or international) scholastic publication.

3. For appraisal conferences of scientific and technical achievements that must be held, the scale should not be excessive, arrangements should be streamlined, attention should be paid to particular results, and formalism should be avoided.

4. For the evaluation and appraisal of scientific and technical achievements, full preparations must be made beforehand according to the rules, and a technically responsible person will be appointed to be in charge of the evaluation and appraisal. Technically responsible people ought to assume a technical responsibility for the achievements that are appraised. There must be no fraud in the evaluation and appraisal, nor favoritism or irregularities, nor the treating of guests or the presentation of gifts, nor squandering without restraint: there may be no invitations to non-technical personnel who have no connection with the evaluation and appraisal. If any of the conditions mentioned above are discovered, it will be the responsibility of the relevant units and personnel.

5. In view of the fact that at present China's management of scientific and technical achievements and appraisal methods are still inadequate and imperfect, it is planned that on the basis of investigation and research we will work out relevant management methods that will be implemented after approval by the State Council.

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SCIENCE, TECHNOLOGY IN BORDER AREAS

Kunming YUNNAN RIBAO in Chinese 10 Oct 85 p 2

[Article by Sun Cuifang [1327 5050 5364]: "Passing On Science and Granting Technology Hastens the Economic Take-off on the Border"]

[Text] Since last year, the science and technology marketplace in our province has been like bamboo shoots after a spring rain in its abrupt development. According to incomplete statistics, more than 10 regions, prefectures, and municipalities throughout the province have held science and technology exchange conferences, have organized hundreds of science popularization fairs, have stimulated broad applications in science and technology, and have given impetus to economic construction at the border.

Opening up technology markets allows science and technology to flow into production as quickly as possible, it is a requirement of contemporary economic construction, and is the urgent wish of the vast majority. The science association of Mengzi County organized a two day science popularization fair, attended by as many as tens of thousands. More than 5,000 jin of improved varieties were sold, more than 8,000 scientific or technical problems were resolved, and more than 8,000 popular scientific books or materials were sold. The Honghe Zhou Scientific and Technical Achievements Trade Fair sponsored by the Honghe Hani-Yi Autonomous Prefecture Science Commission, the Gejiu City Science Commission, and the Yunnan Tin Company Science and Technology Department was held for 7 days in Gejiu City. Business was vigorous throughout. The new product of the Jianshui Sugar Refinery, "bagasse pulp board," resists rotting, insects, and rats, has a low rate of absorbency, has good nail holding and processing performance, can be sawn or planed, can be painted, and its strength is superior to particle board and ordinary fiberboard. It has gained a good reputation, and more than 50,000 yuan worth was sold at the fair. The Chuxiong Yi Autonomous Province held its first science and technology trade fair during Torch Days this year in which 25 units participated, where there were more than 400 items, 4 transactions were concluded in the first 3 days, and there were intentions to sign for 12 other items. The scientific and technical achievements trade fair held by Lijiang Prefecture took place during the traditional mule and horse exchange fair, where there was a crowd of more than 23,000, where the volume of business was more than 55,000 yuan, where more than 2,700 scientific or technical materials were sold or given away, and where more than 200 people were helped with advice. In addition, there were intentions to buy 500,000 jin of red sugar, 500,000 jin of wheat varieties, and 10,000 Ximengde logs. The science and technology markets and science fairs held by the prefectures and counties of Qujing, Dali, Baoshan, Simao, and Jinning were spectacular beyond precedent, where tens of technical service units sprang up, every outfit putting out its sign, objects were spread out for display, graphs and pictures were hung up, and specialists and technicians sat around. With all the talking, questions, and laughing, they got to be called "streets where experience is passed on and treasures sold" by the masses.

The science and technology marketplaces are not only channels to get science and technology into production, but also provide opportunities for the exchange of experiences to town and township enterprises, urban and township individual households, and rural specialty households. The edible mushroom specialist householder of Chengguan Township in Mengzi County, Yin Yuekun [1438 6460 2492], displayed at a street fair the edible mushrooms that he had grown, where more than 10,000 people saw them, and many people contended with each other to buy them. The mature cut tobacco processed by specialist householder He Jiasheng [0149 1367 5116] had in the past been trial sold in an office, where it took a week to sell one package. By advertising at the Mengzi science fair, where there were people both looking and sampling, in two days he had sold 680 packages.

Now, science and technology fairs are a common sight everywhere in this province, not only in the county seats and the interior, but also along the borders in prefectures, villages, and collective townships. Some areas use market days, while others use holidays. The March holiday in Dali, the Torch Day of the Yi people, the Water Sprinkling Festival of the Dai, and the "Danao" (Zongge) Festival of the Jingpo nationality have all held science and technology fairs. When an area holds a science and technology fair, people come from all around. The tide that is the study of science and the use of science is rising higher and higher in our province.

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TECHNICAL SUCCESSES IN NINGXIA MOUNTAINS DESCRIBED

Yinchuan NINGXIA RIBAO in Chinese 22 Oct 85 p 1

[Article by Ma Ying [7456 3841] and Wu Kerang [0702 0344 6245]: "Scientists and Technicians From Units of Academia Sinica Have Had Notable Results in Supporting Construction in Mountainous Regions"]

[Text] In response to an invitation by the autonomous region party committee and government, and under the sponsorship of the autonomous region science and technology commission a "Conference for Scientists and Technicians Supporting Construction in the Mountainous Regions of Southern Ningxia" was held from 10 to 13 October in Yinchuan to confer about and exchange experiences in the support of construction in the mountainous regions of southern Ningxia.

During the meeting, Li Xuezhi [2621 1331 2535], autonomous region party secretary, and Ma Yingliang [7456 5391 0081], vice chairman of the autonomous region, called on scientists and technicians supporting construction in the mountainous regions of southern Ningxia to thank them and express their solicitude.

Units from the Northwest Water Conservancy Research Institute of the Chinese Academy of Sciences and the Forestry Sciences Institute of the Chinese Agricultural and Forestry Sciences Academy began sending scientists and technicians to support construction in the mountainous regions of southern Ningxia in 1980. All together, they erected 19 research and experimental stations in the southern mountains, and on the basis of surveys and research worked on 29 scientific experiments. At present, 27 have been appraised, and 17 have been awarded prizes as great scientific and technical achievements from both the autonomous region and the nation. When scientists and technicians from the Beijing College of Forestry were helping Xiji County in full scale development of afforestation and grass planting, they selected as an experimental site for comprehensive management of small drainage areas the Huangjia village of Ercha in Daping township as an area where conditions were the worst and where management was quite difficult. They carried out simultaneous planning, design, and engineering, came up with both biological measures and engineering measures, and after 3 years of struggle turned around the situation there of extreme deficiencies in the "three feeds." Per capita foodstuff production doubled and income tripled. At the same time, they had worked up a model for the southern mountainous regions to control runoff in water conservation and to implement full scale, comprehensive management. Guan Junwei [7070 0689 5588], a more than 70 year-old professor, gave up the comforts of his later life and joined other scientists and technicians coming to the southern mountainous regions, and rushing back and forth over mountain bridges, made his contributions to the construction of the protective forest project in Xiji. More than 20 scientists and technicians from the Northwest Water Conservancy Research Institute of Academia Sinica developed scientific research work in 15 projects in the counties of Guyuan, Tongxin, and Pengyang. Their projects included comprehensive inspection of resources, protection of natural areas, extension of experiments with the introduction of Hongdou grass, experimental aerial sowing of shadawang, a high yield model for Yinnan pastures and crops, and fuel forest experiments. After 6 years of industrious cultivation, five of the projects were awarded prizes by the Autonomous Region as significant scientific and technical achievements, and the projects as a whole have quickly allowed science and technology to become forces of production. In a situation where plowing has been cut back, the land to be returned to forestry and grazing, food production at Shanghuang Village in Hechuan Township in Guyuan County has still increased annually. And large family livestock has gone from an original 24 head to the current 340. The area has become a model for comprehensive development for mountainous agriculture, forestry, and grazing. Scientists and technicians have helped the public plant 107,000 mu of fuel forest in Pengyang and Guyuan, where the same year that they plant they can receive the benefits, which has been welcomed by the public. Li Li [2621 4539], a middle aged assistant researcher, took up the research topics of shadawang aerial sowing experiments in arid semi-desert regions," "experiments and research into the introduction of Hongdou grass into mountainous regions in southern Ningxia," and "a loess plateau agricultural resource--fuel forest research" in the three counties of Tongxin, Pengyang, and Guyuan, respectively. For over 5 years she has had to overcome serious difficulties until August of this year, when under her supervision shadawang aerial sowing was finally successful at Xiamaguan in Tongxin County with rainfall of 250 mm, which after appraisal is considered to be the first time either in China or abroad. And at the same time, after 5 years of demonstration and dissemination with experiments and research into the introduction of Hongdou grass, more than 30,000 mu has been planted at present in the Guyuan and Yinnan areas, economic results from which have been more than 4 million yuan. The success of these two experiments have provided a scientific basis for recovering vegetation in the mountainous regions, for improving the ecological environment, for controlling water and soil loss, and for dealing well with the construction of grazing land base areas.

Autonomous Region Party Secretary, Li Xuezhi, gave a speech at the meeting. He said: "I represent the Autonomous Region Party Committee and the People's Government in extending our greetings to the scientific and technical workers who have supported construction in the mountainous regions of southern Ningxia, and I express our gratitude to those comrades who once worked here, as well as to the leaders of the units still here. You have worked long in the countryside, where transportation is inconvenient and life is difficult and arduous. However, having the loftiest ideals and having the spirit of serving the people, of serving socialist construction, and of sacrifice to communism, you have been able to overcome all difficulties. We should learn from this spirit of sacrifice that you have." He pointed out that changes in the mountainous regions of southern Ningxia have been great over the last few years. Those changes have been the greatest in those areas where you have developed scientific experiments at the grassroots level, which shows that our work has already been very successful. However, the mountainous regions will not only change their natural appearance, but will also become wealthier, which will require long term, unfaltering efforts. We have already set out on the road to control poverty and achieve wealth, which is an inspiration to cadre and the public in the mountainous regions, which has given hope to the people, and which has strengthened our confidence. In the past, these have been barren hills and desolate mountains, but now they are green, which has been a turn for the better. To have achieved this has been due to the concern and support of the party Central Committee, it has been the result of our carrying out correct principles, policies, and great struggle by the people, but it cannot be divorced from your persistence in carrying out scientific experiments and in developing technical guidance. You have taken up as your own magnificent mission the helping of a people to solve its problems and the changing of the backward appearance of its mountain regions, and have wholeheartedly served the people, unashamedly being good scientists of the people educated under the party. This area will never forget the party nor you.

After Comrade Li Xuezhi had spoken to the conference of the spirit of the national conference of party delegates, he said: In implementing the spirit of the Central Committee conference, scientific and technical workers are facing a formidable and grand task. We hope that after you go back you will diligently study the documents of the conference to strive for scientific and technical advances, and to even better stimulate real action in economic construction in the mountain regions, and to thoroughly implement the spirit of the three Central Committee meetings. Finally, it was his hope that everyone would share their good thoughts, their good experiences, and their good spirit to achieve even greater victories for construction in the mountainous regions of southern Ningxia.

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NATIONAL DEVELOPMENTS

LOCAL S&T ENDEAVOR IN ECONOMIC REFORM DISCUSSED

Beijing KEYAN GUANLI /SCIENCE RESEARCH MANAGEMENT/ in Chinese No 4, Oct 85 pp 40-42, 52

/Article by Zhang Penghui /1728 7720 5057//

/Text/ I. Total Implementation of New Policy on S&T Development

The new policy on science and technology /S&T/ development approved by the party Central Committee and the State Council is not only a guiding policy for S&T development but also one for the development of the national economy. The keywords for the five items in the policy are "rely" and "cater." In the past, it was believed that reliance was the business of the individual departments involved in the national economy and that the S&T Commission mainly catered to and serviced their needs. In fact, this kind of understanding is incomplete. We should pay attention to service on the one hand and to reliance on the other. If one paid attention only to service, one would never be freed from the passive nature of the S&T Commission in dealing with specific projects and would not be able to fulfill the functions of an integrated department and hence not be able to serve well the role of advisor and aide to the party committee and the government.

To implement fully the new policy on S&T development, we initially organized the "Science and Technology Year" activity throughout Henan in 1982 to sway public opinion so that leaders at all levels would pay attention to S&T, that the role and status of intellectuals in the four modernizations constructions would be promoted, and that the initiative of scientists and technicians would be brought into play. To advance S&T further, foundations were laid in 1983 on the basis of what was accomplished in the Science and Technology Year and in areas covering research organizations, research projects, and technical personnel. The year 1985 should be a fruitful year in producing results, talent, and expertise. Our guiding ideologies for the coming year include: paying attention to S&T management and reform, promoting greater integration of S&T with national economy, and fully exploiting technical personnel in order to enhance the role S&T advancements play in the development of the national economy and to promote the progress of the national economy.

From the perspective of individual organizations, individual areas, and individual fronts, whether the new policy on S&T development will be fully implemented, whether S&T will receive proper attention, and whether the S&T endeavor will produce results all depend on the following objective criteria and specific requirements:

a. The research projects chosen must be appropriate and short-term, with reasonable input-output ratios and economic results being constantly improved.

b. The propagation of scientific results and imported advanced technologies should be gradually expanded from the current 30 percent to over 40 or 50 percent in order to elevate society to an advanced level.

c. Among the factors in national economic development, the contributions of scientific achievements should be gradually increased by great efforts from the current 10 percent to 20-30 percent or even 50 percent.

d. More expertise and talent should be dedicated to scientific research and S&T management and their technical and managerial skills should be constantly improved.

e. The proportion of the national economy invested in scientific research should be gradually increased and attention should be paid to the groundwork for scientific research in order to improve the research environment and raise the capability and level of scientific research step by step.

Based on past experience and existing problems, efforts should be made in the following areas in order to implement better the new policy on S&T development and to improve S&T management:

1. Drawing the attention of the leaderships and winning the support of departments. Get out of the confinement of departmental work, get involved in central operations, and advance departmental work while working in central operations. To draw the attention of the leadership to S&T endeavors, one can present S&T accomplishments and summarize the representative examples of S&T-enhancing production and economic development to the leaders and point out existing problems in S&T endeavors and their solutions.

2. Making clear the guiding ideologies. Cater to the needs of the economy and society, encompass economic development, and change from simply paying attention to projects to paying attention to policies, planning, organization, management, and ranks so as to fulfill the functions of an integrated department.

3. Having one's feet firmly planted in the local area, keeping in view the whole nation and setting one's sights on the world. Center around local resources and technological advantages, pick the right targets,

organize coordinated efforts to tackle major projects, and develop premium products and superior industries so as to convert resources and technological advantages into products and industrial advantages; to adhere to combining technology with the economy and with trade, and to accomplish the goal of one developmental project, one specialized corporation, and one superior industry for each local resource.

4. Respecting knowledge, respecting talent, and bringing into full play the role of S&T personnel in the four modernizations constructions. Pay attention to introducing talent from other norms and abroad on the one hand and bringing into full play the role of scientific and technical personnel of one's own area, department, and organization on the other. While implementing the policy on intellectuals, whatever can be offered to outside talent should first be offered to local S&T personnel, because the situation of "winning a son-in-law but losing a son" is absolutely unacceptable. From now on, the focus of talent development should be on the middle-aged and young S&T personnel and not only academic credentials but also competency should be considered. Those with genuine talent and ability should be exploited and the middle-aged and young S&T personnel should be placed in essential positions so as to make the best possible use of manpower and provide an opportunity for it to exercise its abilities.

5. Reinforcing the progress of S&T commissions themselves, constantly improving their S&T management, and bringing into play the initiative of the S&T personnel of the commissions. To accomplish these, a job responsibility system can be set up to link one's performance with economic results.

II. Rural S&T Endeavor Should Accommodate the Trend of Further Deepening the Rural Economic Reform

Since the 3rd Plenary Session of the 11th Party Central Committee, great results have been accomplished in the rural economic reform of Henan and the rural economy has made significant progress. Currently, the new situation of rural reform is mainly manifested in the following areas:

1. After implementing the agricultural responsibility system, the initiative of peasants is brought into play. Year after year rich harvests of grains have been reaped, with a great jump in production. Aside from the grain for internal consumption, seed and animal feed commodity grain increases rapidly and causes problems in the sale, storage, processing, and transportation of grains and cotton. Without proper solutions, the incentive of peasants to produce will be dampened and the agricultural productions affected.

2. Along with the development of agriculture, fisheries, industrial sideline production, the processing industry, and the service industry have also grown significantly with the emergence of a large number of specialized households and S&T households. They are the symbol of the advancement of rural productivity and the goals of a socialist rural economy.

3. With the revitalization of the rural economy and the advancement of productivity, the existing labor organizations have become obsolete and it is natural that new forms of labor organization and a new labor force will emerge. A group of rural specialized households have moved to the urban areas to engage in business and open up factories to serve the needs of urban production and life. In the rural areas, there have also appeared various specialized-technology development companies such as seed companies, plant protection services, fertilizer suppliers, and farm machinery companies. Under the circumstances, peasants have made new demands on S&T endeavors. If we satisfy its needs, the rural economy will make progress; otherwise the progress will be hampered. The peasant's demands are as follows:

1. Demand for better education and more scientific knowledge. More and more peasants realize that education determines their income and that S&T generate profits.

A survey of the Guoji administrative village of Fengtang Township, Yang County, fully demonstrates the relationship of income with educational level.

Of the 198 people in the village, the average per-capita income was 383.70 yuan in 1983.

Among them, eight families with a high school education have an average per-capita income of 509.5 yuan.

Thirteen families with a junior school education have an average per-capita income of 393.6 yuan.

Twelve families with an elementary school education have an average per-capita income of 303.9 yuan.

Seven illiterate families have an average per-capita income of 279.3 yuan.

2. Demand for a prompt supply of accurate S&T and product information. The accuracy and promptness of the information decide whether the undertaking will be a success or failure, or make a profit or lose money. Examples are abundant.

3. Demand for supply of scientific research results and qualified scientists and technicians. In certain cases, often a single breakthrough revives a factory and one able man controls the fate of an enterprise. One good example is the Nanyang Spoke Factory. By adopting a new chromium-plating technology, it has greatly improved the quality of its spokes and quickly occupied a large share of the domestic market.

In order to accommodate the trend of further deepening the rural economic reform and to satisfy the above-mentioned demands, attentions should be paid to the following rural S&T endeavors:

1. Establishing new guiding ideologies for developing rural economy. The traditional, self-sufficient style agriculture of the past works no longer. The new guiding ideologies should be: diversified operations, benign cycles, consolidation of agriculture, industry and commerce, comprehensive utilization, extensive processing, increase of commodity production, and stimulation of the rural economy.

2. Carrying out the strategic study for rural economic development. Make clear the correct direction, route, and policy for rural economic development; make good on long-range development planning; and methodically develop the rural commodity economy based on local resources.

3. Strongly supporting the growth, expansion, and development of the rural specialized households, S&T households, and all kinds of specialized-technology development companies.

4. Fully exploiting rural S&T personnel and skilled craftsmen to enhance the advancement of rural technology and the growth of production.

5. Strengthening the general and technical education as well as the propagation of the popular sciences in the rural areas to continue raising the scientific, cultural, and technical level of the peasant masses, particularly young peasants. Those young peasants who are technically distinguished can be trained at colleges. Effective measures should be adopted to eliminate illiteracy and to solve the problem of admitting school-age children as part of the great effort to cultivate the intelligence of peasants.

6. Giving attention and support to the consolidated planning and construction of new socialist villages and towns and handling well the rural commodity production bases and the technical market.

III. Urban Economic Reform Should Enhance the Technical Advancement of Enterprises

The major goals of enterprise reform were pointed out in the decision on urban economic reform approved in the 3rd Plenary Session of the 11th Party Central Committee, i.e., first, to modify the situation of redundancy and poor coordination and to lessen bureaucracy and control in order to extend the autonomy and to enhance the vitality of enterprises and, second, to adjust the relationship between the individual and the state and to bring into play the initiative of its employees in order to advance commodity production. Under the circumstances, the technical advancement of enterprises becomes particularly important. Therefore, the urban economic reform should enhance the technical advancement of enterprises.

1. Make clear and handle properly the relationship with all sides. Economic reform provides momentum, technical advancement gives vitality, and the economic result is the goal. The economic result mentioned not

only means a profit but should also include variety, quantity, cost, labor productivity, and technical advancement.

2. Adhere to one combination and rely on three kinds of technical forces. At present, there is an acute shortage of technically competent personnel in the frontline of production, particularly for the small and medium-size enterprises. In training people and advancing the urban economy one must adhere to the combination of labor and technology, that is, to win by intelligence and skill and rely on three kinds of technical forces, namely technical personnel, technical workers, and skilled craftsmen. Technical personnel refer to those technical personnel with a college or higher education. They have a sound basic training and are able to take charge of totally technical matters and to assume the leadership in enterprises. Technical workers refer to those middle-aged and young workers with a junior high school or higher education. They have engaged in technical work for an extended period of time, are familiar with the technical matters of their own specialties, and have experience at the basic level. They can be appointed section chiefs, workshop directors, production unit chiefs, and deputy factory directors for production. Skilled craftsmen refer to those with little education but with ample production experience. They have become very good at certain key production techniques and can remedy any problem. They can be organized to participate in technological transformation and technical projects that will advance technology.

3. Emphasize the advancement of technology. The promotion and utilization of scientific achievements and the digestion and absorption of imported advanced technologies should be the breakthrough for the S&T management reform. The cost of technology transfer should not be too tightly controlled and there is no need for a centralized regulation.

4. Focus on product renewal, technology renovation, and managerial improvement. Handle well product design. technical design, equipment design, and production facility planning. Errors in design can cause tremendous waste or cannot even be corrected. Only by constantly improving product design can product renewal be sped up and competitiveness improved.

5. Technical and economic policies should be conducive to the advancement of technology and the growth of production. The policies should define their scope with a certain degree of flexibility. For example, how to support new products, how to set higher prices for better products, how to accrue funds for the technological transformation of enterprises, and how to limit the production of overstocked products should all be specified in these policies.

6. Handle well the construction of scientific research means and bases (such as a new product analysis lab, technical research lab, and product durability testing lab) and pay attention to the application of computers in industrial process automation and business management. Set up various

kinds of new-technology development companies on a trial basis and ensure those specialized companies are geared toward the society and serve the needs of all trades and professions. Those specialized companies should be supervised directly from design and material acquisition all the way to construction and test runs.

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IMPACT OF TECHNOLOGY MARKETS SURVEYED

Beijing ZHONGGUO XIANGZHEN QIYE BAO 2 Nov 85 p 2

[Text] The Chinese International Information Center

This center is an independently accounted joint information and service organization that is composed of more than 30 ministries, commissions, and specialist information research institutes under the State Council, the Beijing Municipal Information Research Institute, and relevant research and design units.

The primary range of services for this center include: to provide for regional economic exploitation and professional technology exploitation information and research reports of a policy making nature; to provide an information service for the capital, special economic zones, open cities on the coast, and frontier regions; to provide an economic and market information service for the importation of foreign new technologies, new sample products, and new equipment; to provide information and technical service for the technical transformation and technology exploitation of small to medium enterprises and town and township enterprises; to provide an information service for the transfer of rights to achievements by scientific research units and scientists and technicians, and to act as a go between for their dissemination; the administration office for the center is at No 74 Dengshikou Dajie in Beijing.

The Fuzhou Technology Market

The permanent Fuzhou Technology Market was officially opened for business on 20 May at the southeast side of the Wu Yi public square. This market was held jointly by the Fujian Provincial Science and Technology Commission, the Provincial Government Office of Economic Cooperation, and by the Fuzhou Municipal Science and Technology Commission. They have entrusted the specific operation to the Fuzhou Center for Exploitation and Exchange of Science, Technology, and Personnel.

The operational scope of the market: to introduce new technology, new techniques, new materials, new products, both foreign and domestic, and to import and transfer the rights to technical achievements for the comprehensive utilization of local resources and management of the "three wastes"; to introduce the transfer of rights to technical breakthroughs and technically innovative achievements that will effectively reduce production costs, that will save energy, and that will improve product quality; to resolve technical difficulties in production for urban and township enterprises, to spread the grand technical restructuring, and to guide the absorption of imported technology.

Shanghai Is the First Technology Market to Open to the Outside

This market is placed in the west auditorium of the Shanghai Gymnasium, occupying 300 sq m. Units from more than 100 organizations in systems such as the Municipal Science and Technology Commission, the Economic Commission, the Shanghai Academy of Science, the higher institutions, defense industry offices, and troops provided more than 600 items, which were the first "commodities" in the permanent technology market. No entrance fees were requested for the fair and there were no rental fees, which allowed both sides to trade freely and to make deals.

Jiangxi Has Begun Technology Fairs

Technology markets are just beginning in Jiangxi. At present, 70 counties (or prefectures) have begun technology fairs. The technology markets of Jiangxi began testing in April of last year, where the technology markets in each area launched technical service activities, chief among which are the following: 1. spread advanced technology and help the public open doors to wealth; 2. develop technical consulting services, compensated science popularization services, and technical training services; 3. carry out compensated transfer of the rights to technology and technical contracts; 4. compensated assembling of talent and organizing compensated technical guidance contingents.

Shenyang Municipality Technology Markets Develop a Positive Function

Since the Shenyang Municipal technology markets began in 1980, they have been a positive influence.

1. They have stimulated the transfer of technical achievements into production, and they have encouraged the technical advancement of enterprises. In recent years there have been 11,264 contracts for the transfer of technology. Based on a survey of the more than 1,500 technology contracts already completed, more than 700 million yuan in profits has been realized.

2. They have advanced the restructuring of the science and technology system. Technology commercialization has changed the situation where in the past science and technology units "depended upon upper echelons for expenses, where tasking was passed from above to below, and where achievements were reported to the upper levels."

3. They have stimulated the transfer of military industrial technology to civilian use. In 4 years military industry units have concluded 2,049 contracts with Shenyang civilian enterprises to transfer the rights to technology, which has already become the mainstay of the Shenyang technology market.

4. They have stimulated improvement in the standards of teaching and scientific research. One quarter of the technology contracts taken on by Dongbei Engineering Academy have been selected as topics to train graduate students. One teacher on the staff of this institution trained five graduate students with the subject he had accepted, and cooperated with his comrades to write three textbooks.

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METALLURGY INSTITUTE GEARS UP FOR S&T DEVELOPMENT

Shanghai JIEFANG RIBAO in Chinese 8 Nov 85 p 1

/Text/ The Shanghai Metallurgy Institute of the Chinese Academy of Sciences has geared itself for the economic construction, adhered to reform, and actively and selectively engaged in S&T development. In recent years, S&T development projects of the institute cover a territory stretching from the three northeastern provinces in the north to the Shenzhen Special Economic Zone in the south with collaborating organizations scattered about some 50 locations within 18 provinces and municipalities. An economic benefit of 170 million yuan has been produced for the society.

Reform has generated a refreshing vitality for the institute and has changed the traditional, biased view that scientific researchers who undertake applied research are inferior. Researchers have moved into social studies and surveys and now realize the importance of bringing the strengths and advantageous conditions of the institute into full play. Through the establishment of lateral contacts with the departments dealing with the national economy, 17 projects that are technically feasible and have a key importance were initially chosen. By means of promoting scientific achievements, technology transfers, consulting services, and the establishment of cooperatives, it has opened up a new situation for development.

In order to strengthen lateral contacts and coordination, the Shanghai Research Center for Metal Corrosion and Protection Technology, the Metallurgy Institute being its pivot, was established with the approval of the municipal S&T commission. The bigger projects accepted so far include the anticorrosion work on the diversion pipeline for the Huangpu Jiang. The original plan specified that the diversion pipeline last for 60 years. After further study, it was concluded that the useful life of these pipelines can be extended to 80-100 years with pipeline protection measures. Through arrangements such as technology sharing and financial investments, the Shanghai Metallurgy Institute has formed joint research and production enterprises with local organizations. The institute has formed a joint venture for producing specially shaped aluminum alloy materials with Tai County, Jiangsu. Phase one of the construction is completed and is in the process of being tested. The estimated production output is 10 million yuan. In the area of developing magnetic materials, the institute has formed a production co-op with Wu county, Jiangsu. The business started production in September.

For those research projects that will produce big economic results, are technology-intensive, and are difficult for local enterprises to undertake, the institute carries out the batch processes through its newly formed pilot-scale development diversion in order to develop some successful products for the institute.

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S&T AWARDS CEREMONY HELD

Kunming YUNNAN RIBAO in Chinese 10 Nov 85 p 1

/Text/ The 1984 Yunnan S&T achievement awards ceremony was held at Kunming's Science and Technology Building on 9 November 1985 and 183 instances of excellent S&T results were awarded, in which 136 were basic research results and 47 were promotion results.

Among them, 2 items won first rank awards, 16 second rank, 66 third rank, and 99 fourth rank. These awarded achievements are the careful choices of the provincial S&T advancement award evaluation committee. The majority of them are of a higher academic level, some are at the forefront at home, and some are advanced by international standards. A substantial number of the results are new items developed by utilizing the resource advantages of theprovince and are readily applicable. They have played significant roles in the economic construction and social development of the province.

At the ceremony, Liu Zhibin /0491 2535 2430/, chairman of the evaluation committee, reported on some issues concerning the 1984 S&T results evaluation. He commented that to give correct evaluations to S&T results and to award the S&T workers and S&T management personnel who made contributions is to show the party's and government's concerns for S&T and their expectations of S&T workers. S&T workers should remember well the trust of the party, make great efforts to climb to new heights in science, and create more advanced S&T results in order to make great contributions to the progress on this province's economy and to China's socialist modernization. Zhang Jiaoluo /1728 2043 5012/, director of the provincial S&T commission, was present to congratulate the award winners.

Comrades in charge of S&T works at all provincial committees, offices, and bureaus as well as colleges and universities, comrades in charge of S&T commissions in every city and prefecture, and members of the provincial S&T advancement award evaluation committee--over 300 people altogether--attended the ceremony.

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list in an effort to carry out the task of promotion and application. This region attended the first national technical trade meeting and made exchanges worth over 5 million yuan. At the advanced industrial technology exchange meeting of the five northwestern provinces and regions which was held in this region, we made technical trades that amount to over 10 million yuan. These technical results flow into enterprises and villages where they are converted into products. According to the survey of the four institutes (architectural engineering, light industry, chemical engineering, and mechanical engineering), their technology-generated revenues for the first half of the year are several times more than those of all of last year. The Ningxia Architectural Engineering Institute is close to self-supporting.

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TIANJIN'S SCIENTIFIC ACHIEVEMENTS DURING 6TH 5-YEAR PLAN

Tianjin TIANJIN RIBAO in Chinese 12 Nov 85 p 1

[Article by She Dede [0152 0344 1795]: "Tianjin's Bumper Crop of Scientific Achievements during the 'Sixth 5-Year Plan'"]

[Text] Tianjin harvested a bumber crop of scientific achievements during the "Sixth 5-Year Plan" because it has firmly oriented science and technology toward economic construction.

Statistically, from 1981 through September this year, over 1,000 achievements from the municipality won national and municipal awards, including 35 which obtained national invention awards. At the 13th International Invention Exhibition in Geneva in 1985, 4 projects from Tainjin won 5 awards, including two gold medals, one Asian grand prize, one gold-plated medal and one silver medal. In addition, 40 Tianjin projects won the recently announced national scientific and technological advancement prizes.

An outstanding feature of these award-winning achievements is that the vast majority of them have obvious social and economic results. An analysis of 129 achievements which were candidates for this year's national scientific and technological advancement award shows that 99 have increased economic results for the state by 800 million yuan. "The technology of vacuum industion overlay welding of exhaust valve in internal combusion engines," which won the National Invention Prize, Class 3, uses 60 percent less alloy compound metal than the world's most advanced welding technology and is at least 6 times more productive than the most advanced technology at home. It has been widely adopted in a dozen factories in China so far, its contributions to economic results about 5 million yuan annually.

The modernization of the technology and products of old enterprises and the improvement of their productivity have been accelerated considerably by the application of a host of scientific research achievements which require little capital but produce quick results. After their adoption in the city and the rest of the nation, such new materials or processes as XZ-revolving thin-film evaporator, ground covering technology, new permanent-magnetic materials, nitriding titanium imitation-gold coating, artificial incubation of white crucian carp, artificial matching of bait for prawn, and new green fodder and corn varieties have all produced outstanding economic results.

Tianjin has also laid a fairly solid scientific foundation in such up-and-coming technologies as microcomputer technology and software, optical communications, laser technology, biotechnology and new materials. If only we work hard to create the right conditions, we can expect to create certain new industries in the "Seventh 5-Year Plan" period.

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ECONOMIC, TECHNICAL COOPERATION BETWEEN PRC, EEC

Beijing GUANGMING RIBAO in Chinese 19 Nov 85 p 1

[Article by Wu Fengzhou [0702 6646 0719]: "Economic and Technological Cooperation Between China and the EEC Continues to Develop"]

[Text] This is the 10th anniversary of the establishment of relations between China and the EEC. Since the establishment of relations, joint efforts by both sides has led to continual development of relations between China and the EEC.

Since China began to implement open door policy in 1979, China has developed economic and technical cooperation relationships with many nations on the basis of the principle of equality and mutual benefit. China is working gradually to perfect its legal regulations for economic ties with foreign countries, guarantee the legal rights and interests of the holders of technology, and provide excellent environmental conditions for foreign businessmen for investments and technical transfers. The efforts we have made in this area have received praise and support from the related countries' governments, and from business and financial circles. During these few years, the economic and technical cooperation relationships between China and the EEC have expanded continually. Of the foreign economic trade contracts for technical imports that were examined and approved in the 4-year period from 1981 to 1985, import contracts with the nations of the EEC totaled $1.8 billion. In the 9 months of 1985 alone, there were 168 contracts worth more than $1.1 billion. There has been a substantial increase in the number of contracts and amounts involved in contracts signed between China and the Federal Republic of Germany, and it leapt from third to first place in proportion of technical imports to China. More than four times as many contracts were signed with France in 1985 than in 1984, and the number of contracts signed with Italy and England have more than doubled in comparison with the same period in 1984. There also have been substantial increases in the number of contracts and amounts involved in contracts signed with other EEC nations.

To achieve better organization of EEC projects, we must not miss an opportunity to develop work with the outside. In 1985, the Ministry of Foreign Relations and Trade made four visits to nations of the EEC and received warm welcomes from the governments and business circles of these countries. We feel that the size of a nation or an enterprise is not important. The main thing is that they must have advanced technologies that meet China's needs, in which case we all are willing to adopt various forms of cooperation. China has more than 400,000 enterprises, most of them medium and small enterprises. Most of the enterprises need to carry out technical transformation and will need to build a substantial number of new capital construction projects in the future. The range of cooperation with the EEC is extremely vast.

With adherence to the principle of equality and mutual benefit, relationships of economic and technical cooperation between China and the EEC will continue to expand.

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S&T LEGISLATION DISCUSSED

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 25 Nov 85 p 2

/Text/ Along with the advancement of the reform of China's economic system and its S&T system, the strengthening of legislation in the S&T area has appeared more and more frequently on the agendas of important meetings. Marxist laws consider the formulation and exercise of laws and regulations the basic form of governing a state. There is no doubt that they are also an important measure for causing S&T to flourish and enhancing the coordinated development and close integration of S&T and economic construction. To hasten the pace of China's S&T modernization construction, a task of top priority is to strengthen S&T legislation.

S&T Legislation refers to the drafting, promulgation, and revision of S&T laws and regulations. There is no consensus at home or abroad as to what constitutes an S&T law. It is generally held that it is the collection of laws and regulations governing all kinds of social relationships in S&T activities. The matters to be governed include not only the overall S&T decision-making, forecasting, and planning but also detailed S&T research, development, and management. They further include the relationship between overall and detailed S&T activities. In human history, the emergence of S&T laws is not a random, accidental occurrence. Rather it is the result of the great advancement of modern S&T. Because S&T have become the enormous assets of modern society, the development of a social economy depends more and more on the progress of S&T. The new technological revolution is changing the social relationships formed in the people's social production activity and social life. Therefore, only by applying the laws that reflect the nation's S&T development, i.e., "positive, definitive, and universal regulations," to handle properly relationships among the state, collective, and individual, the relationship between man and nature and relationships among different areas of S&T in S&T undertakings can the advancement of S&T be greatly enhanced, their social functions in social production and social life by fulfilled, and they become truly the cornerstones in raising social productivity. Simply for these reasons, the legislation of many countries since the end of World War II, especially from the 1970's to the present, is no longer focused on politics as it used to be. Rather it has been shifted to the areas of S&T and the economy. This is the challenge to traditional laws by S&T, or rather the "merger" of science and law.

The formulation of S&T laws and regulations can be traced back to the Yanan era in China's revolutionary history. During that period, the Chinese Soviet government issued about eight laws and regulations such as the "Measures for Rewarding Production Technology" and "Regulations on Remuneration for Cultural and Technical Cadres" that played positive roles in the consolidation and expansion of the red base. Over 10 regulations including "Provisional Regulations for the Protection of Invention and Patent Rights" were also formulated right after Liberation. However, like the whole socialist legal system of China, S&T legislation suffered a serious setback during the 10-year catastrophe of the "Great Cultural Revolution." It was not until the 3rd Plenary Session of the 11th Party Central Committee that S&T legislation made new strides along with the development of the economic system and S&T system reform. Nevertheless, legal construction in the S&T area has a long way to go when the requirements of S&T modernization construction and the objective needs of S&T system reform are considered.

Today we are carrying out legal construction in the S&T area under the circumstances of the reform. Therefore, it bears special significance. Just as many comrades pointed out at the recently held national symposium on S&T legislation, there was a "change of laws" accompanying every reform in history. Reform requires legislation and legislation enhances reform. At present, the party and state have formulated the strategy and policy that "economic construction must rely on S&T and S&T must be geared toward economic construction." Also a series of important and correct policies were made in the "Decisions on S&T System Reform by the Central Committee of the CPC." In carrying out the reform, millions of people have gained abundant experience. The tasks of S&T legislation are to solidify, put in clauses, and standardize in a timely fashion the national policies on S&T development and the successful experience of the masses in carrying out the reform so that they are transformed into rules of action whose enforcement is guaranteed by the power of the state and by which the results of the reform can be consolidated and expanded in order to realize a series of strategic goals and policies of the party and state for S&T development. Just as the teacher of revolution, Lenin, said: "If it is the will of the state, it should be expressed in the laws formulated by the organs of political power. Otherwise, the word 'will' is a meaningless sound." Consultations with both experts and the masses are required in studying what S&T regulations ought to be formulated. We believe that S&T regulations should be a relatively independent and integrated branch of the socialist legal system and that S&T legislation ought to cover the major areas as follows:

(1) Formulation of laws and regulations on S&T administration that specify the system and principles of state and local S&T management and the responsibility, authority, and personnel selection and appointment system of the administrative organizations at all levels.

(2) Formulation of laws and regulations on S&T planning that clearly define the principles, approach, content, management system, and hiring schedule in S&T development planning and the execution, examination, and supervision as well as reward and punishment system of the plan.

(3) Formulation of S&T civil laws that govern the property relationships and the personal non-property relationships including the right to inventions, discoveries, and S&T results of legal persons and citizens in S&T activities.

(4) Formulation of S&T labor laws that guarantee the right and freedom of citizens to engage in intellectual exercise and specify the wage, allowance, vacation, advanced study, labor protection, and reward and punishment systems of S&T workers.

(5) Formulation of laws and regulations on S&T to establish a system that deals with the exploitation and utilization of natural resources, the distribution and usage of facilities and equipment, and the management of information, literature, and files.

(6) Formulation of laws and regulations on financing S&T to establish allocation, loan, budgeting and final accounting, tax, and risk investment systems in the state's support of scientific research and technology development.

(7) Formulation of laws and regulations on S&T promotion to enhance the research, development, and propagation of those advanced and applied technologies of great significance by legal measures.

(8) Formulation of laws and regulations on S&T that involve foreign affairs to solve a series of legal problems that will emerge in the process of implementing the open-door policy, developing the import-export trade of technology, and carrying out international S&T cooperation. Naturally, S&T legislation is a tremendous task to perfect China's socialist upper structure and is absolutely not something that is done with a stroke of the pen. It needs the total cooperation and long-term efforts of S&T, economic, and legal circles. This year the State S&T Commission and related departments have engaged in the formulation of a technical contract law and are actively studying the formulation of research institute laws, S&T labor laws, regulations on mass organizations in natural sciences, and technology import-export laws as well as several ordinances, stipulations, and measures for supporting the S&T system reform. This is a good start. We believe that along with the perfection of the legal construction in the S&T area, China's S&T modernization will move forward at a faster pace and a new situation will emerge in China's socialist legal system.

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PATENT APPLICATION RECEIPTS DISCUSSED

Beijing GUANGMING RIBAO in Chinese 29 Nov 85 p 1

[Article: "China Has Received More Than 12,000 Patent Applications, Two-Thirds of Them From Inside China and One-Third From Foreign Countries, Which Worldwide Is Considered To Be the Optimum Structure"]

[Text] Deputy director An Yutao [1344 3768 3447] of the Chinese Patent Bureau stated at the National Technical Progress Work Conference on 25 November 1985 that China's recently-born patent system has great vitality and may make a contribution to technical progress, improvement of economic results in enterprises and implementation of policies concerning intellectuals in China. According to statistics from the Chinese Patent Bureau, the bureau had received 12,649 domestic and foreign patent applications in the three categories of inventions, new uses and exterior design by 23 November. Two-thirds of them came from within China and one-third from foreign countries. This is considered to be the optimum structure worldwide.

According to our understanding, China will have received an estimated 14,000 patent applications by the end of 1985, ninth or eight place worldwide.

The interesting thing is that patent rights for many inventions and innovations have been transferred immediately after the applications are submitted, and some of them even have provided quite considerable economic benefits. Advanced engineer Yan Mengqiu [7346 1322 4428], director of the Shaping Energy Conservation Equipment Plant in Shaping Township, Changsha County, Hunan Province, has submitted a total of four patent applications to the Chinese Patent Bureau for an "oil burner for industrial boilers," a "diesel burner for industrial boilers" and other devices. After examination and approval for meeting specifications by the Patent Bureau, they were announced publicly inside China and abroad on 10 September. His inventions now have been extended to more than 80 factories. The Changsha Dyestuff Plant spent 4,000 yuan to install a diesel burner for industrial boilers before the announcement. It greatly increased product quality, reduced environmental pollution and conserved work time, and it resulted in a 56.2 percent fuel savings and provided more than 400,000 yuan in benefits within only 5 months. After using two oil burners for industrial boilers that burn heavy oil, the Benxi [Liaoning] Iron and Steel Company's Rolling Mill rapidly achieved high quality production and the average oil savings was 36.3 percent.

Industrial boilers in China burn about 40 million tons of crude oil and heavy oil and about 2 million tons of diesel each year. If Yan Mengqiu's invention were extended universally, we could conserve about 6 to 8 million tons of crude oil, heavy oil and diesel each year and create about 1 billion yuan in value. In addition, Yan Mengqiu could receive very subtantial royalties for the transfer of patented technology. According to statistics from the Hunan Patent Bureau, more than 90 inventions and innovations have been put into actual use in the province, and they may provide the state with more than 34 million yuan in taxes, and provide the patent transferrer with more than 3.8 million yuan in benefits.

In Beijing Municipality, the Beijing Patent Office alone has acted as an agent in the signing of 16 patent transfer contracts during the first 7 months of 1985 that will provide the state with an additional 40 million-plus yuan in benefits and the inventors with more than 2 million yuan in royalties for the transfer of technical patents. Some items already have attracted the interest of foreign businessmen.

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NATIONAL DEVELOPMENTS

SHENZHEN SEZ SCIENTIFIC RESEARCH WORK DEVELOPS QUICKLY

Beijing GUANGMING RIBAO in Chinese 30 Nov 85 p 1

[Article: "Scientific Research Activities Have Developed Rapidly in the Shenzhen Economic Zone—Import From Abroad and Transfer Within, Strive to Develop Scientific Research and Product Development"]

[Text] Since its creation, the Shenzhen Special Economic Zone [SEZ] has been active in linking up with advanced forces in the interior and importing advanced technologies from abroad in a major effort to develop scientific research and product development. Up to the present time, the SEZ has completed many S&T projects with rather high economic benefits, including 36 projects that received Shenzhen City superior S&T achievement awards. This was the situation outlined by Shenzhen CPC Committee Secretary Liang Xiang [2733 3276] at the First Shenzhen S&T Work Conference that opened on 27 November.

Liang Xiang said that before the SEZ was established, Shenzhen had only 27 technical personnel whose primary duties involved the application of technology in agriculture, forestry, animal husbandry and fisheries. They lacked basic scientific research and experiment measures. In the years since the SEZ was founded, the number of specialized scientific research organizations in Shenzhen municipality has grown to 12, and there are 8 enterprise technical development organizations and 15,000 S&T personnel of various types, including 8,300 with college or higher educational levels, more than 80 with advanced job titles and more than 2,300 with middle level job titles. In addition, there are large numbers of S&T personnel working in joint investments with concerned departments at various levels and assigned to units in Shenzhen. Liang Xiang said that this is the most solid force both for achieving rapid development of scientific research in the SEZ and for taking a major step toward the "technology window."

Administrative expenditures and equipment used for scientific research in the Shenzhen SEZ have increased every year. Administrative expenditures for scientific research in 1985 equalled the sum total for the previous 3 years and were 25.6 times as much as before the SEZ was established. There have been substantial increases in scientific research and testing measures, instruments and equipment.

Many enterprises and scientific research units in the Shenzhen SEZ have focused on cooperation with the interior for establishment of associations that integrate scientific research, education and production. This has been effective in promoting technology imports and in testing and development of new products and new technologies. Examples include four items of "dual-concentrated" technology and equipment imported by the former Shenzhen City S&T Development Company, the SDH-A Chinese character generator developed successfully by the Shenzhen Electronics Research Institute, a flat fluorescent display and components and a high brilliance color super-large screen flat display tube developed by the Fenghua Electronics Industry Trade Company, and they have applied to the state in 1985 for three patents including one for a matrix fluorescent display. The Shekou Huanqiu [Global] Electric Machinery Company has developed electric machinery at international levels, and all their products are being exported.

In the area of linkages established with S&T forces in the interior, Shenzhen has concentrated on importing foreign advanced technologies and equipment. During the first half of 1985, the city imported more than 30,000 pieces (sets) of various types of instruments and equipment including a digital program controlled information exchange system and electroplating additive technologies from the United States, color television production lines and magnetic recording production lines from Japan, four-color closed and open printing machinery and airflow spinning and weaving technologies from West Germany, universal gate digital computer switchboards from Sweden, laser sightsinging technologies from Holland, oil paint production lines from Denmark, hollow core glass technologies from Austria and so on, and all of them are at advanced international levels.

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ADJUSTMENT OF INTERNAL RELATIONS OF SCIENTIFIC PERSONNEL

Beijing GUANGMING RIBAO in Chinese 10 Dec 85 p 2

[Article by Zheng Haining [6774 3189 1337] and Wang Shaoding [3769 1421 0002]: "Adjusting the Internal Relations of the Scientific and Technical Contingent"]

[Text] In a recent interview with reporters, Zhou Guangzhao [0719 0342 0664], vice president of the Chinese Academy of Sciences, emphasized that the nation has a high-caliber scientific and technical contingent comprising hard-working personnel who are steeped in party education and love socialism fervently. We must have complete trust in them and rely on them. We must unleash their enthusiasm with policies and adjust the internal relations of the contingent so that every person can do what he does best. We must encourage them to contribute to the common objective--the promotion of economic construction and the development of China's science and technology."

Zhou Guangzhao said, "Based on the party's science and technology policies, the Chinese Academy of Sciences is currently mobilizing its subordinate research institutes to integrate their own work with economic construction. Some research institutes and offices must actively cooperate with enterprises and localities to organize developmental research or to stress such research in their applications in order to speed up the conversion of scientific research achievements into productive forces. For this reason, we must select some scientific and technical personnel and train them in business and management so that they can handle developmental work. We must correct the mistaken notion that only people unfit for scientific research will go in for development."

Zhou Guangzhao said, "A majority fo the scientific research projects at the Chinese Academy of Sciences are applied research. These projects are essential to the development of the national economy and must be accomplished." He emphasized, "The Chinese Academy of Sciences absolutely must not slacken its effort in long-term scientific research, i.e., basic research which will influence the national economy and social development beyond the 1980's. In accordance with the spirit of the resolution of the CPC Central Committee on the restructuring of the scientific and technological system, we must continue this kind of basic research in a steady, sustained way. We must prevent topic proliferation and overlapping. Selected projects which have great significance must be given the necessary conditions and qualified personnel to ensure that the research bears fruit as soon as possible. We must ensure funds for basic research, applied research and other major research tasks of the state. We must also ensure a stable livelihood for scientific and technical personnel involved so that they can devote themselves to research wholeheartedly. We must do a good job in every type of work--scientific research support services, organizational management and social service work. We must correctly evaluate all kinds of labor."

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INTEGRATED RESEARCH-PRODUCTION ORGANIZATIONS

Beijing GUANGMING RIBAO in Chinese 13 Dec 85 p 1

[Article: "China Now Has Nearly 10,000 Scientific Research and Production Associations--The Scope of Integration Continues To Expand, the Content Is Becoming Broader Day by Day, Various Forms of Integration Are Providing Advantages, Speed, and Benefits and Effectively Promoting Economic Construction"]

[Text] Emerging technical and economic organizations--scientific research and production associations--have undergone vigorous development in China in recent years. To date, an estimated nearly 10,000 associations of various forms have been set up in China. The scope of integration is expanding continuously, the content of integration continues to grow day by day and the integration has assumed a variety of forms.

Further intensification of reforms in S&T systems in China has been accompanied by the establishment of associations in most provinces, cities and autonomous regions across the country. Several trial points in Dalian, Shanghai, Beijing and other places have developed into actual implementation. The scope of associations extends through industry, agriculture, medicine, urban construction, environmental protection, communications, energy resources and other realms. The content of the integration has developed from technical transfers and development of new products to technical transformation within an enterprise, important topics within an industry and comprehensive technical and economic development within a region.

The associations come in many forms, and the overall tendency has been development from low to high levels:

They have developed from single-item technical cooperation to contractual responsibility to integrate an entire process. The contractual responsibility companies have integrated design, manufacture, construction, installation and other units to unify their pace and coordinate tacit understandings, which has shortened construction schedules considerably. The Shanghai Jihua Air Conditioning Engineering Contractual Responsibility Company has assumed contractual responsibility for transformation of a 2,500 square meter plant building that was turned over for use after only 4 months.

They have developed from coordination of key special scientific research topics to the integration of scientific research concerning multiple specializations and multiple disciplines and interdepartmental and interregional integration of specialized production.

They have developed from national coordination of research and development to international research and development.

They have developed from single item technical transfers to joint integrated administration.

The integration is providing advantages, speed and results, and it has been effective in promoting the development of economic construction. After the Guangzhou City Pharmaceutical Industry Research Institute linked up with the Guangzhou City No 4 Pharmaceutical Plant to form an association, research achievements in the institute were converted quickly into new products in the plant. The plant moved from losses to yearly profits in excess of 2 million yuan and there have been major improvements in the scientific research conditions and living conditions within the research institute. The Jialing Brand Motorcycle Association headed by Sichuan's Jialing Machinery Plant has made new investments of about 7 million yuan over the past 4 years to form a production capacity of annual output of 300,000 units and final assembly of 500,000 units a year. It has become the largest motorcycle plant in China in output, and it saved two-thirds of the investments needed for building a new enterprise of identical size.

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SSTC ON COOPERATION BETWEEN INSTITUTES, ENTERPRISES

Beijing GUANGMING RIBAO in Chinese 17 Dec 85 p 1

[Article: "Higher Education and Scientific Research Units Should Integrate With Large- and Medium-sized Enterprises--Guo Shuyan [6753 2885 6056], Deputy Director of the State Science Commission Talks With GUANGMING RIBAO Reporters--Forms Must Conform to Content, Be Concerned With Practical Results, Advocate Diversification and Do Not Act Indiscriminately"]

[Text] Guo Shuyan, deputy director of the State Science Commission, told reporters from the GUANGMING RIBAO that development of various forms of integration of scientific research and production should be accompanied by a concern for the integration of scientific research units and institutions of higher education with large- and medium-sized enterprises. There can be varied forms of integration. In conjunction with the short-term need for conscientious service to production, research units also should have specific technical reserves.

Guo Shuyan pointed out that most of the organizations that integrate scientific research with production in recent years involve links among scientific research and educational units with medium- and small-scale enterprises and township and town enterprises. They have played an obvious role in invigorating the local economy. This point must be acknowledged fully and should continue to develop in the future. At the same time, attention must be given to integration with large- and medium-sized enterprises. China's large- and medium-sized enterprises are the lifeblood of our national economy. Improvements in their ability to absorb and develop technology is linked with development of the national economy and improvement of technical levels. Some institutions of higher education and large and medium-sized enterprises in China should establish more linkages with them in various forms. Although it is true that key large and medium-sized enterprises depend on the motive force and vitality of technical progress to no lesser of a degree than medium and small-scale enterprises and township and town enterprises, further intensification of reforms in economic systems and increased vitality within the enterprises will make them increasingly dependent on technical progress. Scientific research and educational units in China should take note of this point.

While discussing the forms of integration between scientific research and production, Guo Shuyan also said that the forms of integration should conform to contents, be concerned with practical results, advocate diversification and avoid indiscriminate action. The actual forms adopted should be based on reality and conform to local conditions.

Guo Shuyan fully affirmed the role of scientific research and design units and institutions of higher education in the development of integration of scientific research and production. He also emphasized that at the same time that these units support their short-term need to serve production, they must also have a certain amount of technical reserves and continue to develop reserves so that integrated scientific research and production organizations can have even stronger vitality.

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EFFECTIVE WAY TO PROMOTE TECHNOLOGICAL ADVANCEMENT

Beijing BEIJING KEJIBAO in Chinese 20 Dec 85 p 1

[Article by Jin Zhude [6855 2612 1795]: "The Civilianization of Military Technology Promotes Technological Advancement"]

[Text] After 3 decades of development, China's national defense, scientific and technological work has established a fairly solid, comprehensive and technically advanced foundation. We now have a large quantity of technology and advanced equipment and a scientific and technical contingent comprising highly qualified people. We have obtained a substantial number of technical achievements in the research and production of both conventional and nuclear weapons, some of them innovations in the nation and some reaching or approaching advanced international standard.

In line with the principle of military-civilian integration, the national defense scientific and technical industry in recent years has been actively transferring military industrial technology to the civilian sector even as it tries to fulfill our research and production tasks pertaining to weapons and armaments and continues to develop the production of civilian commodities. This transfer has powerfully boosted progress in civilian industrial, technological and economic development and provided obvious economic results. For instance, the Ministry of Aeronautics applied and popularized the satellite temperature control technology in such industries as textiles and metallurgy with excellent economic results in fuel conservatation, etc. They made the nation's largest heat pipe and exchanger for Anshan Iron and Stell Works, which not only shortens steel-smelting time and improves the productivity of a steel-smelting furnace, but also saves 700,000 yuan each year in fuel costs, equivalent to 3 times the unit price of hot pipe heat exchanger. In yet another example, the Ministry of Aeronautics used its technological superiority to help Tianjin integrate its output transformer production line with the result that the line's technological functional index reached advanced international standard. It also programmed microcomputers to control key equipment, increasing annual profits of each production shift by 1.2 million yuan. Nuclear technology has also been extensively applied in many areas including radiation processing, irradiation breeding, food preservation, sterilization and disinfection, medical diagnosis, tracer probing, analysis and surveying. Through the transfer of technological achievements to civilian sector, joint military-civilian research, the establishment of joint ventures with civilian units, contracting, miscellaneous forms of economic and technical cooperation and the offering of extensive consulting services, the various national defense scientific, technical and industrial units are now transferring to the different sectors of the national economy technical wealth accumulated over many years.

Looking at events in recent years, the transfer of military technology to civilian use essentially takes the following forms: (1) the transfer of technical achievements (software); (2) the simultaneous transfer of technical software and hardware. This includes the transfer of technology along with the product as well as the application of military industrial technology to various areas of national economic construction through all manner of joint operation and contracting; and (3) military industrial personnel provide society with various kinds of technical services. Experience proves that the transfer of military industrial technology is an effective approach to promoting technical progress, integrating science and technology with production and raising the standard of social productive forces. As transfer became widespread, it has stimulated the rise and prosperity of the technical market and ushered the national defense scientific and technical industry into a new stage during which it contributes to the national economic development at various levels, in various forms and through various channels, even as it fulfills its tasks in weapons and equipment research and production.

Despite the initial achievements of the national defense scientific and technical industry in recent years in transferring military industrial technology to civilian use, the military industrial technology still has great potential and can play an even more important role in economic construction. To exploit to the full the technological superiority of military industry, the departments and localities concerned as well as military industrial enterprises, institutions and other units should take this vital force into consideration when they draw up development strategies at any level. We should further study and grasp the characteristics and laws of technology transfer and, on the basis of that knowledge, formulate and perfect a system for the transfer of military technology to civilian use together with relevant laws and regulations, and gradually solve such problems as funds and material channels so that the civilianization of military industrial technology can proceed more successfully and with better results.

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NATIONAL DEFENSE SCIENCE, TECHNOLOGY DEVELOPMENT STRATEGY

Beijing BEIJING KEJIBAO in Chinese 20 Dec 85 p 1

[Article by Xi Qixin [1153 0796 2450]: "Conference on National Defense Science and Technology Development Strategy Held in Beijing"]

[Text] After 7 days of in-depth consideration and deliberations, the national defense science and technology development strategy conference closed in Beijing a few days ago. Research on national defense science and technology development strategy is an important component of building up a modern military with Chinese characteristics. Without such research, national defense science and technology research and weapons research will become haphazard and not be able to meet the needs of our military in future anti-aggression wars. The recent conference which examined the short-, medium- and long-range goals of China's arms development in a broad context, taking into account the country's conditions, was of profound significance for the development of our military. Leading comrades on the Central Military Commission urged comrades on the national defense scientific, technological and industrial front to carry on and strengthen our glorious, decades-old tradition of overcoming adversity, of diligence, struggle, self-reliance, unity, cooperation, courage, creativity and remaining undaunted in the face of difficulties.

The national defense science and technology development strategy conference was organized by the National Defense Science, Technology and Industry Commission and attended by over 200 experts and scientific and technical personnel from the headquarters of the General Staff, various arms of the services, relevant government ministries and departments and relevant units of the Chinese Academy of Sciences. This was the first time China organized such a large-scale conference to explore the national defense science and technology development strategy in a comprehensive and coherent way. Ma Hong [7456 3163], chairman of the Economic and Technological Research Center, the State Council; Ding Henggao [0002 5899 7559], chairman of the National Defense Science, Technology and Industry Commission; Zhu Guangya [2612 0342 0068], and Qian Xuesen [6929 1331 2773], chairman and vice chairman respectively of the Science and Technology Committee of the National Defense Science, Technology and Industry Commission, and other experts all presented papers at the conference dealing with various specialized topics. The conference has enhanced our understanding of the importance of national defense science and technology development strategy research and our sense of urgency about stepping up such research. The conference also achieved a certain measure of agreement about the guiding ideology, procedures, contents, organization and methods of strategic research. Conference delegates believe that the meeting marks a new beginning in China's national defense science and technology development strategic work and will have a positive and far-reaching impact on defense modernization and national economic construction.

12581/13167
CSO: 4008/2047

NATIONAL DEVELOPMENTS

STATUS REPORT ON PATENT LAW

Hong Kong JINGJI DAOBAO [ECONOMIC REPORTER] in Chinese 1 Jan 86 p 70

[Article by Wang Xidong [3769 2569 2639]: "Patent Law in Action"]

[Text] From 1 April 1985 when the "Patent Law of the People's Republic of China" came into effect on 9 September the same year, the State Patent Bureau received 9,867 patent applications, of which 6,080 applied for invention patents, 3,364 for utility and novelty patents and 423 for industrial design patents. Chinese enterprises, institutions and individuals were responsible for 6,632 applications while 3,235 were filed by foreigners.

On 10 September 1985, the State Patent Bureau held a press conference in Beijing at which Director Huang Kunyi [7806 0981 4135] announced the first batch of patent applications, including 46 applications in the invention category, 65 in the utility and novelty category and 39 in the industrial design category. Among them were 26 foreign applications and 43 individual applications.

At the same time, the State Patent Bureau has published a booklet on this batch of patent applications, another on the examination and approval procedures and a third on the application for a utility and novelty patent. They were made available for nationwide public distribution together with the announcement.

It is about these developments that the reporter interviewed Director Huang Kunyi. He said, "With the announcement of the first batch of patent applications, the implementation of the Patent Law has taken a big step forward. It shows that patent work is developing surely and steadily in China and that we have begun our own patent literature and are building up a comprehensive technical file on our own inventions and innovations, which should play an important role in the dissemination of information on inventions and the popularization of new technology."

Director Huang Kunyi said, "From now on, China's patent literature will be a new addition to the 30 million pieces of patent documents in the world collection today. We may say this is of historical significance."

He said, "New China's first Patent Law was promulgated and went into effect on 1 April this year. Earlier, on 14 September 1984, the Eighth Session of the Sixth National People's Congress standing committee decided that China should join the 'Paris Convention on the Protection of Industrial Property' in order to cooperate with the world to promote such protection. After the Patent Law took effect, many enterprises and individual overseas indicated their desire to take out a Chinese patent and considered the promulgation of the law a landmark in the history of industrial property protection in the world. Over the past few months, the Patent Bureau received over 3,000 overseas applications, evidence enough of the high level of interest abroad in the establishment and implementation of China's patent system."

He pointed out, "Judging from the number of announced patent applications, the percentage of foreign applications remains quite small, about 1.7 percent of all announced patent applications. On the other hand, about 33 percent of all applications received by the Patent Bureau comprise foreign applications. Why?"

Director Huang Kunyi provided an explanation. He said, "As we all know, the Patent Law involves foreign relations as well as being a piece of domestic legislation. It was promulgated to develop China's economic and technical exchange and cooperation with the world as well as to protect domestic invention and innovation. The publication of the first batch of patent applications was based on three considerations: (1) patent applications made a request in their applications for substantive examination and early announcement; (2) the application papers were well prepared, which facilitates processing; and (3) the applications were submitted relatively early, the bulk of them on 1 April."

China and the rest of the world follow different timetables when it comes to announcing patent applications. Elsewhere, applicants usually request a time lag of 18 months before their applications are made public. This is another reason why the percentage of announced foreign applications is so small.

Director Huang Kunyi said, "China encourages foreigners to take out a patent in China. Our regulations provide that a foreign applicant who first applied for a patent abroad after 1 October 1984 may request priority in accordance with the law when he applies for a patent in China. The signs are that the percentage of foreign applicants will increase gradually."

Director Huang Kunyi said, "The Bureau's examination department has begun to classify patent applications and is carrying out the first round of preliminary examination. Some of the invention patent applications have entered the stage of substantive review. Relevant departments in the bureau are working intensively right now."

The State Patent Bureau currently employs over 200 substantive examiners in for substantive examinations departments each looking after different technical fields. All examiners hold scientific or engineering qualifications from institutions of higher education and most have considerable practical experience and are familiar with the techniques of their own specialties.

They have also been trained in the Patent Law and the practice of patent examination. In addition, the State Patent Bureau has specifically set up a classified file for inspection.

Director Huang Kunyi said, "In most cases examiners and applicants exchange opinions in the course of examination and many applicants amend their applications in accordance with the law."

About the publication of patent applications before the bureau approves them, he said, "We announce them to give people an opportunity to object to a particular application. This is also an important way of ensuring the quality of our examination and approval process."

He said, "Often the manufacturing method of identical or similar products is being researched, produced or applied in more than one unit, so the objecting process is essential to both research and production units. Say someone wants to take out a patent on a product or process which has already been published in journals, or been manufactured successfully by another unit and applied or popularized in actual production. In this case, the objecting process must be made full use of to prevent the person from obtaining the patent he seeks. Otherwise a patent dispute may possibly arise."

Director Huang Kunyi said, "Of course, the Patent Law provides that after a patent is granted, any person who knows of any reason why the patent should have been denied may ask the Patent Review Committee to declare the patent null and void. Still, 'prevention is much better than cure.'"

Director Huang Kunyi continued, "The Patent Law provides for a 3-month objecting period, beginning with the day when the application is announced. Only if no objection is raised during this period or if the objection is found to have no merit will the bureau proceed with the decision to award the patent and present the applicant with a patent certificate. The matter will be recorded and announced. Only at this point is the application considered to have been approved and only then does the patent formally take effect. But the Patent Law and its detailed regulations give temporary protection to a patent application after it has been published or announced, that is, after the substance of the invention or innovation becomes public knowledge. No individual or unit is allowed to use the invention at will. To use it, he must pay a use fee of an appropriate amount and obtain it through technology-transfer procedures."

Director Huang Kunyi said, "Under the Patent Law, a patent application is entitled to provisional protection only after the bureau has announced or published it. To help foreign readers keep track of China's patent information, therefore, China's patent bulletin and booklet will be distributed to various nations through exchange. Also, in the interest of easy reference, the Patent Bureau will publish a digest in English of patent applications in China in order to promote the interflow of patent information. At present the Patent Bureau has established patent literature exchange relations with 14 nations and 2 international organizations." Director Huang Kunyi said that colleagues and patent experts overseas are welcome to raise objections to patent applications we have announced.

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ANHUI GOVERNOR ON SCIENCE, TECHNOLOGY WORK

OW140419 Hefei ANHUI RIBAO in Chinese 2 Feb 86 p 1

[Excerpts of Governor Wang Yuzhao's speech at a meeting of the Anhui Provincial Scientific and Technological Association to greet veteran experts]

[Excerpts] Esteemed veteran experts and esteemed friends and comrades of scientific and technological circles:

With the advent of the first spring of our great motherland's Seventh 5-Year Plan, the provincial Scientific and Technological Association is holding this ceremonious meeting to greet the 80 veteran experts who have worked for 50 years in the field of science and technology. This is a happy event not only for the scientific and technological circles but also for the people at large in our province. On behalf of the Anhui Provincial CPC Committee and the provincial people's government, I respectfully extend warm congratulations and pay high respects to these veteran experts! I also wish to avail myself of this opportunity to extend sincere regards to all comrades working in the field of science and technology in the province.

Currently, we have entered a new period, a period for implementing the Seventh 5-Year Plan. To continuously advance on the basis of the excellent situation in our province, to further develop our urban and rural economies, and to turn our province's great blueprint for the Seventh 5-Year Plan period into splendid reality, the people across the province should work hard in unity under the party leadership and should continue to thoroughly implement the policy of reforming, opening, and invigorating. But in particular, we must speed up our technological advance, expedite the training of competent personnel, and increase the use of science and technology in supporting various tasks. This is an unshakable responsibility and an arduous but glorious task on the shoulders of comrades working on the science and technology front. In view of this, I wish to make the following earnest requests on behalf of the provincial CPC committee and the provincial people's government to all comrades present at this meeting and to the broad masses of science and technology workers in the whole province:

1. Persist in carrying out reforms and make continued efforts to thoroughly implement the decision of the CPC Central Committee on reform of the science and technology management system and the regulations promulgated by the provincial CPC committee and the provincial government relative to this reform.

It is imperative that we adhere firmly to the correct orientation in carrying out the reform in the field of science and technology. The objective of this reform is to fully arouse the initiative of the broad masses of science and technology workers so that their great "Potential" can be tapped through the implementation of correct policies. Success or failure of the reform in the field of science and technology depends on whether the initiative of science and technology workers has been stirred up, whether their work has produced greater results, and whether more new competent workers have been trained.

2. Mobilize to give more science and technology support in rural work. This is the key to further development of the rural economy. The No 1 Document (1986) of the party Central Committee stresses: The guidelines that "science and technology must serve the rural economy while the development of the rural economy must rely on science and technology" should be regarded as an important principle and given prominence. We hope that our comrades of science and technology circles will take account of our province's actual conditions, earnestly study and understand this principle, and enthusiastically provide rural areas with science and technology. They should educate peasants in science and technology. They should use science and technology to support village and town enterprises and provide complete technical service to peasants so as to help them solve the problem of poverty and become better off.

3. Go all out in the work of applied technological research and popularize the application of such research results, orient the work toward enterprises, open science and technology markets, and help enterprises promote technological transformation and advance. The enterprises now have a very urgent need for technological transformation and advance and are showing greater and greater capabilities to transform and develop themselves. In such circumstances, there is much for the broad masses of science and technology workers to do. They should orient their work toward the enterprises, enthusiastically provide the enterprises with good service, and work in concert with the enterprises' technical personnel to make due contributions to improving product quality; reducing consumption; assimilating, digesting, and improving foreign technology; accelerating the improvement of products; formulating development plans for the enterprises and even for the whole industry; improving operations and management; and raising overall economic results.

4. Earnestly train competent personnel and bring up a strong contingent of scientists and technicians. This is a glorious task that history has given to the scientific and technological circles as well as to education workers. We now have a relatively big contingent of scientists and technicians, but the numbers of scientists and technicians are still insufficient and their quality is not high enough. Because of this, they are far from adequate in meeting the needs of the four modernizations. In addition, the composition of our contingent of scientists and technicians is not entirely reasonable. As far as scientists and technicians are concerned, they have not only the task of scaling the heights of science but also the task of training new competent personnel and the task of making further studies to catch up with the development of advanced technology in the world.

5. Make more contributions to the work of building highly developed socialist spiritual and material civilizations. Scientists as well as the broad masses of workers in the science and technology field should, through their industrious work, promote not only material civilization but spiritual civilization as well.

6. It is hoped that the leadership at all levels will be concerned about the thinking, work, and livelihood of veteran experts as well as science and technology workers and support their work. It is necessary to make it a general practice in the whole society to respect knowledge and to honor competent people. Opinions and suggestions of science and technical workers should receive earnest attention, and their role should be brought into play in formulating macro policy decisions. In addition, it is necessary to know them well, make good use of their ability, and respect their pioneering spirit. Cases of attacking and persecuting science and technology personnel should be investigated and dealt with promptly. All these are aimed at further implementing the policy concerning intellectuals and bringing into full play the socialist enthusiasm of science and technology workers.

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CSO: 4008/2063

SHIFT IN NATION'S NUCLEAR INDUSTRY STRATEGY OUTLINED

Beijing LIAOWANG [OUTLOOK] OVERSEAS EDITION in Chinese 3 Feb 86 pp 3-4

[Article by Gu Mainan [7357 6701 0589] and Gu Wenfu [7357 2429 4395]]

[Text] Spring arrived early at Zhongnanhai this year. Although it is still in the middle of winter, willow trees along the shore are beginning to sprout, symbolizing that spring was around the corner.

In the afternoon of 21 January, ten scientists and engineers from the Ministry of Nuclear Industry joined by Minister Jiang Xinxiong and Deputy Minister Chen Zhaobo enthusiastically walked into the Huairen Hall of Zhongnanhai. Included in this group are the silver-haired nuclear-chemical engineer Jiang Shengjie, the nuclear physicist Wang Ganchang, senior engineers and scientists Liu Xingzhong, Min Yaozhong, Huang Qitao, Yu Min, Lian Peisheng, Qian Gaoyun, Lu Dexian, and Sun Zuxun. The ages of these gentlemen range from 78 to nearly 80. During the past three decades, they have struggled along with other colleagues from snowy highlands to the Gobi Desert, and have made outstanding contributions to the development of China's nuclear industry and strategic nuclear weapons, as well as to the peaceful use of nuclear energy. Now, the initial phase of nuclear development is behind us, and China is entering the period of the Seventh Five-Year Plan. The 300,000 workers of the nuclear industry are ready to write the next chapter in the history of nuclear development--a chapter on the peaceful use of nuclear energy.

The peaceful use of nuclear energy covers many different areas; an important question is to decide where to concentrate our national resources. When Party leaders and government officials announced that they wanted to meet directly with the scientists, the scientists were overjoyed and immediately went to work to prepare for suggestions which they brought with them to Zhongnanhai.

No sooner had the scientists taken their seats in the Huairen Hall, government leaders Hu Yaobang, Fang Yi, Li Peng, Yang Shangkun and Hao Jianxiu walked in. Minister Jiang Xinxiong introduced each one of the experts to the leaders, and after an initial round of socializing, they all gathered for a group picture. Hu Yaobang and Yang Shangkun walked over to Jiang Shengjie and Wang Ganchang and said: "Elderly comrades, please take the front seats!"

The meeting began in a lively and harmonious atmosphere. Hu Yaobang said: "Comrades in the nuclear industry, you have made valuable contributions for the Party, for the country, and for the people. Thanks to your dedicated efforts, we have successfully developed our own nuclear weapons, strengthened our defense posture, established a comprehensive nuclear industrial system, and built a top-notch team for the nuclear industry. The Party Central Committee, the State Council, the military services and the Chinese people will never forget the historical contributions you have made for us!"

In these few short statements, the General Secretary summarized several decades of hard work, dedicated pursuit, struggle, hardship, and joy of these experts and other personnel of the nuclear industry. Officials and scientists of the Ministry of Nuclear Industry were deeply moved by his remarks.

"The comrades indeed made a tremendous contribution." Interrupted Hao Jianxiu, smiling, "In 1964, as I was passing through Italy on my way home from Albania, I was unable to get an airline ticket. Just at that time, the news covering China's explosion of its first atomic bomb reached the airport, and knowing that I was from China, the airline personnel immediately sold me a ticket!"

Then Hu Yaobang continued his speech by saying that it was his hope that comrades in the nuclear industry would now diversify to support the development of consumer industries and to make new contributions for the cause of socialist economic development.

"Of course, in the past, you were in an ivory tower; everyone supported you and paved the way for you. Now, we hope you will take a few steps and come down from the ivory tower!" Hu said, with a smile. Everybody responded with laughter.

Prior to this meeting, Vice Premier Li Peng had toured several nuclear facilities including the Qinshan nuclear power plant which is currently under construction. He pointed out at the meeting that China's basic policy of nuclear development is to redirect its main resources to the development and utlization of nuclear energy while still maintaining the current level of military and industrial production. The first priority for the Ministry of Nuclear Industry should be to develop nuclear power; of course, they should also get involved in other consumer industries. The initial phase of developing China's nuclear power plants has been very difficult, but at least we have taken the first step. To develop nuclear power, we should consider self-reliance our primary goal, but we certainly will also take advantage of the advanced technologies from other countries.

He told the audience: "The Secretariat of the Central Committee and the State Council have made a preliminary decision to delegate the entire responsibility of research, development, and construction of nuclear power plants to the Ministry of Nuclear Industry. Therefore, comrades at the Ministry of Nuclear Industry will have greater freedom to apply their skills and talents. In making his remarks, Li cast a hopeful glance at the nuclear experts.

Hu Yaobang also agreed with Li's announcement about delegating more authority to the Ministry of Nuclear Industry. He hoped that various units of the Ministry would take the initiative to establish close contacts with local industries, other industrial and mining organizations, and small businesses in towns and villages, and send technical personnel to support these local activities. He also pointed out that in the area of peaceful use of nuclear energy, we can consider developing cooperative relations with other countries.

Next, Fang Yi took the floor and said: "It is also very important to maintain a strong research team in the nuclear industry by constantly recruiting new members. In addition to research in the peaceful use of nuclear energy, I am also hopeful that new contributions will be made in the areas of nuclear chemical engineering, isotope research, and laser research. In short, comrades of the Ministry of Nuclear Industry will have unlimited opportunities and a very bright future!"

Some experts at the meeting also expressed their opinions. They were particularly pleased to hear that the Ministry of Nuclear Industry will be given full authority to develop nuclear power. They pointed out that today, there are 26 countries capable of building their own nuclear power plants. In some developed countries, 50 percent of the energy supply comes from nuclear power. In building 10 nuclear reactors, we have accumulated considerable experience and established a comprehensive nuclear industrial system; we have also trained a highly qualified team of experts. With the full support and cooperation from other industries and organizations, we are confident that this important mission given to use by the Party and the State can be accomplished. Some experts pointed out that this assignment is what the 300,000 members of the nuclear industry have been hoping for. By the end of this century, total industrial and agricultural output will quadruple, hence the demand for electric power will also increase. If we rely totally on thermal electric power, the cost of transporting several million tons of coal from North to South will be unacceptably high, not to mention the adverse effect of environmental pollution. In order to solve China's energy problem in the 21st century, it is essential to follow the path of developing nuclear power; if we do not start now, it will be too late. Therefore, we believe that this decision by the Central Government is timely and correct. Some scientists observed that during the 50's and 60' when conditions were extremely difficult, we successfully built nuclear reactors in the Gobi Desert by relying on our own talents and resources; today's conditions are much better than those of that period. Furthermore, with today's open-door policy, we can supplement our own resources with advanced technologies from abroad; hence we have full confidence in successfully completing our mission.

The meeting concluded after more than 2 hours. The scientists left Zhongnanhai full of confidence and hope. After the meeting, they immediately conveyed the message to every worker in the nuclear industry. A major issue that had become a popular topic of discussion was how to adapt one's job to this shift in strategy. In this regard, Minister Jiang Xinxiong, Deputy Minister Chen Zhaobo, and scientists Jiang Shengjie, Wang Ganchang made some interesting remarks worth pondering. They said that the development of nuclear power plants, like the development of atomic bombs and hydrogen bombs, must depend on the cooperation of other ministries and departments. Relying on the Ministry of Nuclear Industry alone is not sufficient. Although we have been given the primary responsibility, we must coordinate with other ministries and departments. In the development process, we must remember the valuable advice given by Premier Zhou Enlai: "Be serious in your work. Pay attention to details. Do not overlook any minor issues, no matter how small. That is the only way to ensure that nothing will go wrong." We can say that our mission is completed only after one, two, three reactors have been built and have been demonstrated to operate safely in a power network.

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WEN WEI PO ON PRC'S ANTARCTIC RESEARCH

HK210559 Hong Kong WEN WEI PO in Chinese 17 Feb 86 p 2

["Newsletter from Antarctica" by correspondent Juan Chi-hung: "China's Scientific Research in Antarctica"]

[Text] In November last year, China sent another 39-man Antarctic observation team to conduct research at the Great Wall station on King George Island. Twenty-nine members of the team will spend summer there, while 10 others will stay through the winter and return to China early next year. What kind of scientific research are they doing exactly?

The land mass least known to mankind, Antarctica is also the only unpolluted continent, and a treasure house for scientific research. Geologists search for evidence in an attempt to prove whether the land was linked to the mainland or not million of years ago. A Beijing student who once settled down in the countryside in Xizang in 1966, Liu Xiaohan, is today a geologist with a doctorate degree from a French university. He believes that the South Shetland Islands (King George Island is part of this island group) were separated from the Antarctic mainland due to the sinking of land slates [ban kuai 2647 1040] some 2 million years ago, and that the South Shetland Islands are essentially an isolated island group similar to Japan and the Philippine archipelago. Data gathered by marine geologists indicates that the underwater gap between the South Shetland Islands and the Antarctic mainland measures 70 km, and the surface distance is 100 km.

Possible Oil Deposits

Liu Xiaohan carries a travelling bag and hammer and explores the area around the Great Wall station every day in search of evidence. He picks up rocks, notes down their exact location, marks the place, and brings the rocks back to the station for analysis. If it can be established that the South Shetland Islands are indeed an isolated island group, then more evidence should be available to further verify the proposition that Antarctica was linked to other great land masses further back in time. Liu has already found a tree fossil in King George Island which proves that the island used to belong to the Asian temperate zone. If it can be proved that this is an isolated island, then it is possible that oil deposits could be found on the sea bed, as has been the case with other isolated islands.

Giving Up Postgraduate School to Study Grey Dust

Jia Guoqiang, a young geophysist from Beijing University, gave up the chance to do postgraduate studies in the United States, and instead came to the Antarctic region to spend the winter here. His field of study is aerosols. In simple terms, aerosols are the suspended matter in the atmosphere, otherwise known as grey dust. Jia installed a tube-like sampling gadget with distilling papers placed at different levels in order to catch grey dust of various sizes. After gathering samples from different places and under different weather conditions, the samples will be brought back to China and put inside an accelerator, where they will be powdered and their components studied. This will be similar to grey dust which settled layer after layer on icebergs thousands of years ago, and should provide a valuable record of world climatic changes. Jia Guoqiang's study is significant in the study of world climatic history and weather forecasting.

This is an important item in the Antarctic research program. Air convection is not only an atmospheric problem. The United States uses airplanes to gather samples from all layers of the atmosphere in order to study the speed and direction of the spread of nuclear dust after nuclear bomb explosions. For its study of a nuclear winter, Australia burned an entire forest, then observed the weather changes under snow conditions. In Antarctica, there is no need to burn up forests in order to obtain freezing conditions.

Seismographs Were Also Installed

The United States and the Soviet Union have both installed seismic prospecting devices in Antarctica. The aim is to find out in which corners of the earth the other side has conducted nuclear tests. China also intends to set up a seismograph in the region. Aside from the above-mentioned purpose this will also be helpful in earthquake prediction.

Ordinary people only know how to appreciate the natural beauty of the Antarctic region, while scientists hope to learn about the varying weathering processes on the rocks of the mountains, to find out about the marine life beneath the calm waters and its distribution, hydrology, water temperatures, sea tides; and earth tides. All these fall into the sphere of study of oceanologists.

China's Antarctic scientific observation is just at the preliminary stage and a great deal of the work involves basic scientific research and collection of data. In fact, much of the work is repetition of work already completed by other countries. However, in the absence of a system for the exchange of scientific results, it is necessary for China to conduct this research. Moreover, this basic scientific research serves as a solid foundation for further research in the future.

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NORTHEAST TECHNOLOGICAL DEVELOPMENT GROUP ESTABLISHED

SK180711 Shenyang Liaoning Provincial Service in Mandarin 2200 GMT 17 Feb 86

[Excerpt] The Northeast group for the application and development of new technology, an integrated economic and technological organization characterized by meeting the needs of opening to the outside, was formally established in Shenyang on the morning of 17 February. With the support of the three provincial governments in Northeast China, the group was jointly established by the Dalian Institute of Chemical Physics, the Changchun Institute of Optical and Precision Machinery, the Shenyang Institute of Automation, and the Shenyang Institute of Metal under the Academy of Sciences of China; the Ministry of Chemical Industry, the Shenyang Institute of Chemical Industry, Dalian Engineering College, Northeast Engineering College, Jilin University, Harbin Industrial University, the Shenyang Aircraft Industrial Company, the Shenyang (Liming) Machinery Company, and the Shenyang Company for the application and development of new technology on a mutually beneficial basis and in the light of the principle of voluntarily making concerted efforts for development.

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CSO: 4008/2063

APPLIED SCIENCES

EMISSION MECHANISM OF OXIDE CATHODE

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol II No 2, Mar 83 pp 33-39

[Article by Zhang Enqiu [1728 1869 5876] of Institute of Electronics Chinese Academy of Sciences: "Electron Emission Mechanism of Oxide Cathode*"]

[Text] Abstract: The energy levels of single crystal BaO, SrO and CaO measured from thermal electrical conductivity, photoelectric conductivity, photoelectron emission and absorption spectra are so diverse that accurate energy band diagrams cannot be obtained. This suggests that the surface energy levels are more important than the bulk levels. The work function of single crystal BaO film on Ir(100) is single-valued. This is inconsistent with the wide distribution of total work function of carbonate measured by a low energy scanning electron probe, indicating that the semiconductor model cannot be used to accurately describe the oxide cathode. It was found that the coating was richer in oxygen than alkaline earth metal after 2000 hours by Auger electron spectroscopy. However, the capability to emit electrons was not affected. Thus, the oxygen vacancy donor concept is invalidated. The fact that excess barium are electron emission sources can be reconciled with decreasing alkaline earth metals during life by the dynamic surface emission center model. This model suggests that an aggregate of alkaline earth metal oxide molecules with excess absorbed barium atoms can effectively emit electrons. This concept can be used to interpret many phenomena observed on oxide cathodes using modern surface analysis techniques.

I. Introduction

Oxide cathodes are simple, efficient and widely used electron sources. However, there is still no satisfactory theory to describe their electron emission mechanism. In the semiconductor model introduced earlier[1,2], an oxide cathode is considered as a p-type semiconductor with excess barium as the donor. But, various theories derived from this model did not agree with phenomena observed experimentally. For example, the single crystal electrical conductivity, inhomogeneity of emission, instability at high current densities, and initial electron velocity distribution cannot be satisfactorily explained by the semiconductor model.

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*Received in Jan 82, finalized in Mar 82.

We had analyzed a great deal of experimental data from China and abroad and proved that the semiconductor model does not agree with the essence of an oxide cathode[3]. Later, we introduced the dynamic surface emission center concept[4] in which an aggregate of atoms with excess absorbed barium is believed to be the electron source. In recent years, there has been some new data. Most of the work was done using advanced surface analyzers in ultrahigh vacuum. These results further illucidated the essence of oxide cathodes. The purpose of this work is to re-examine our concept with the new data in order to investigate the characteristics of oxide cathodes.

II. Single Crystal Study

The basis of the semiconductor model is the single crystal. Then, a study of the single crystal could gain some profound understanding about oxide cathodes. In reality, however, single crystal measurement did not yield a clear concept. Instead, some serious discrepancies were found. Figure 1 shows the relation between electrical conductivity and temperature for single crystal BaO, SrO and CaO under different conditions.[5]

From the figure one can see that the zero scatter is considerably from either the numerical value of electrical conductivity or its slope (i.e. the internal work function in the semiconductor model). This is a surface state effect because the surface state is susceptible to the influence of the preparatory condition and the experimental environment. It is worthwhile to note that the electrical conductivity of the colored crystal (Curve 1) is higher than those of other transparent crystals. However, its internal work function is also higher (2.1 eV) than those of other crystals. It is also larger than the total work function of BaO (1.6 eV). The color in the center indicates the presence of trapped electrons in the oxygen vacancy, suggesting that the single crystal is in an excited state. A transparent single crystal then has no crystal defect, corresponding to a poisoned state. Experimental results showed that the internal work function of an excited single crystal is higher than that of a poisoned one. It is also larger than the total work function of BaO, which disagrees with practical oxide cathodes in use.

According to the semiconductor model, a cathode is activated by increasing the number of oxygen vacancy donors. The result is that the energy level of the donor will get closer to the conduction band to lower the internal work function. This also means that an increase in electrical conductivity should be related to a decrease in work function. However, Figure 1 shows that there is no specific correlation between the internal work function and electrical conductivity in a wide range of experiments involving different activation methods, annealing conditions and vacuum. This suggests that the activation concept in the semiconductor model cannot reflect the essence of oxide cathodes.

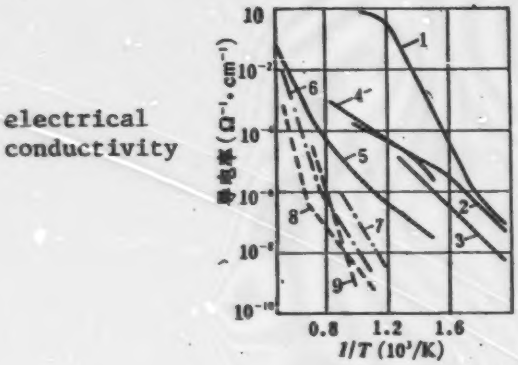

图 1 BaO、SrO、CaO 单晶导电率与温度倒数的关系
——BaO 1．1473K钡蒸汽中染色的晶体，
2．1000K真空中退色的透明晶体，
3．真空中的透明晶体，
4．甲烷中激活的晶体，
5．不良真空下(10^{-2}Pa) 的透明晶体。
—·—·SrO 6，7
------CaO 8，9

Figure 1. Electrical Conductivity vs. Inverse Temperature for Single Crystal BaO, SrO and CaO

Key:

1. Dyed Crystal in 1437 K barium vapor
2. Transparent Crystal Discolored in 1000 K Vacuum
3. Transparent Crystal in Vacuum
4. Crystal Activated in Methane
5. Transparent Crystal in Poor Vacuum (10^{-2} Pa)

One can also see from Figure 1 that the electrical conductivities of SrO and CaO are far smaller than that of BaO. Their internal work functions (if they really exist) are larger than that of BaO, which indicates that the contribution of oxygen vacancy to electron emission in Sr and Ca is negligible. However, the electron emission of a composite crystal of mixed BaO, SrO and CaO is significantly higher than that of BaO. The total work function ϕ and temperature coefficients are as follows[6]:

$$\left.\begin{array}{ll} \text{BaO} & \phi=(1.6\pm0.08)+(5\pm1)\times10^{-4}T \\ \text{(BaSr)O} & \phi=(1.2\pm0.05)+(5\pm1)\times10^{-4}T \\ \text{(BaSrCa)O} & \phi=(1.1\pm0.05)+(5\pm1)\times10^{-4}T \end{array}\right\} \qquad (1)$$

where T is the absolute temperature. These experimental data were found to disagree with the derivation based on the semiconductor model. If we use the concept of the dynamic surface emission center, then the presence of Sr and Ca favors the formation of a low work function emission center which increases the energy levels to facilitate the transfer of surface electrons. It can absorb more excess barium atoms to prevent the evaporation of active materials[4]. These arguments are in agreement with the results obtained in practice.

In addition to thermoelectric conductivity discussed above, studies on photoelectric conductivity, absorption spectra and photoelectron energy spectra can be used to locate the energy level of the single crystal. Moreover, these results can be used for mutual verification. Nikonov attempted to obtain a clear energy level diagram by combining the data on BaO single crystal in these four areas. As he admitted that he was unable to plot an accurate energy band diagram from the available data. He believed that at least there are bulk energy levels at 1.2, 2.0 and 2.6 eV from the bottom of the conduction band to the donor as well as surface energy levels at 1.0, 1.4, 2.0 and 2.6 eV on the vacuum scale[5]. Although he did not get the anticipated result based on the semiconductor model, yet the data pointed out a problem. Even in a single crystal, the role of surface energy level is very important. It is even more so in a porous polycrystalline cathode.

It is clear that the semiconductor model for oxide cathodes cannot be verified by using single crystals. It is then not surprising that certain phenomena observed with polycrystalline cathodes could not be interpreted by this model. All objective facts forced us to focus our attention onto surface problem.

III. BaO Thin Film Deposited on Ir Substrate

Haas et al deposited a thin BaO film on Ir(100). It was used as a collector to observe the maximum and minimum current in the current-voltage curve with a single energy electron beam. The corresponding electron energies could be used to calculate the internal and external work functions. According to Bragg's reflection principle for a normal incident electron beam, the de Broglie wavelength of the electron, λ, in the conduction band of single crystal BaO should satisfy

$$n\lambda = 2d \qquad (2)$$

where d is the lattice constant and n is any integer. Let $\lambda = h/p$, h is Planck's constant, and P is the momentum of a conduction band electron, then the energy $\varepsilon = P^2/2m$ (m is the effective mass of the electron). After cancelling P and λ, we get

$$\varepsilon = \frac{h'^2}{2m}\left(\frac{\pi n}{d}\right)^2 \qquad n = 1,\ 2,\ 3\cdots\cdots \qquad (3)$$

where $h' = h/2\pi$. When the electron energy in the conduction band satisfies Eq (3), electrons are reflected in the Bragg mode to form a standing wave, as shown in Figure 2. The collected current is the minimum. When n becomes (n-0.5), the electron wavelength is out of phase with the lattice constant and there is little reflection. The collected current is the maximum, i.e.

$$E\uparrow = \frac{h'^2}{2m}\left[\frac{\pi(n-0.5)}{d}\right]^2 + E_c \qquad n = 1,\ 2,\ 3\cdots\cdots \qquad (4)$$

where $E\uparrow$ is the electronic energy corresponding to the maximum current. Because the Fermi level was used as the reference in the measurement, it is necessary to add E_c which is the energy from the bottom of the conduction band to the Fermi level. Haas et al believed that E_c is the internal work function and the external work function can be obtained by subtracting E_c from the total work function. Furthermore, they also measured changes of internal and external work functions under various conditions of thermal activation, electron bombardment and oxygenation poisoning[7,8].

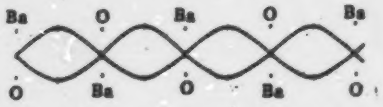

Figure 2. Schematic Diagram of Standing Wave of Electrons in Conduction Band Lattice

Initially, this experiment seemed to support the semiconductor model for oxide cathodes. Haas et al had the same feeling. However, a detailed analysis showed that it could not be used as evidence to prove an oxide cathode is an n-type semiconductor because:

1. The key to the semiconductor model is in the donor. In this experiment, electrons are injected into BaO and they move in the conduction band. Those not reflected enter the iridium substrate to become the measured current. Therefore, the entire experiment did not involve any donor activity. Because donors are distributed all over the thin film, the standing wave shown in Figure 2 would be destroyed if donor electrons jumped to the conduction band or conduction electrons down to the donors. Then, Eq (2) could not be satisfied. This is in contradiction to the basic principle of the experiment. The work functions measured in that work were due to the surface states at the BaO-Ir and BaO-vacuum interfaces. The changes of E_c with activation or doping is probably due to adsorbed oxygen on iridium just as measured with an Auger spectrometer shown in reference [8]. This phenomenon can be explained by the concept that the work function can be lowered if an appropriate amount of oxygen is adsorbed on the metal surface, but too many adsorbed oxygen atoms will cause it to rise again.

2. The experiment was conducted at room temperature with an injection current less than $1\mu A$, which is far different from the operating condition of an oxide cathode. Therefore, the results cannot illucidate the mechanism of an oxide cathode. The same group adopted an opposite approach to develop a practical cathode by covering an iridium film on BaO. In addition, the BaO was not monocrystalline. They discovered that active materials could diffuse along the iridium surface. When using an electron microscope, they were able to cleanly observe emission centers[9], suggesting that appropriate aggregates on the metal surface might also emit electrons. This coincides with the concept of dynamic surface emission sites.

3. In an article published later, Haas[10] had changed his opinions in references [7,8]. When they injected a $2\times10^{-3}A/cm^2$ electron beam onto a BaO single crystal film, the electrical conductivity was found to be greater than $4\times10^{-8}(\Omega\text{-cm})^{-1}$, which is two orders of magnitude higher than that of BaO single crystal at the same temperature, $10^{-10}(\Omega\text{-cm})^{-1}$. Hence, it could not be explained by the electrical conduction mechanism in a semiconductor. Consequently, they introduced the surface conduction concept. After measuring the temperature coefficient of the work function of single crystal and polycrystalline BaO, they found that their temperature coefficients are basically identical. The work function of polycrystalline BaO is lower. They were forced to believe that the variation of the work function with temperature is not due to Fermi energy changes in the bulk. Instead, it is affected by the surface state, i.e. the external work function. In addition, when they were determining the external work function of M_gO on single crystal Mo(100), concepts such as Fermi energy level, forbidden bandwidth and internal work function were not used. This shows that the team was in the process of exploring the truth and they did not believe that their viewpoints should remain unchanged.

IV. Research on Practical Oxide Cathodes

Haas et all studied ternary salt cathodes in detail and obtained a lot of useful data[12]. First they used a low energy scanning electron probe technique to measure the work function distribution of ternary salts at 915 K as shown in Figure 3. We can see that the difference between high and low work function is above 1 eV. This is difficult to interpret by the semiconductor model. Because each particle is in contact with others, electrons can move freely in the conduction band as long as they jump from the donors to the conduction band. Even though the donor concentration in the coating is not uniform, the electron concentration in the conduction band is still homogeneous because electrons can move easily. Therefore, the inhomogeneity of electron emission is primarily due to difference in the external work function. But, the numeric value of external work function is less than 1 eV according to the literature (measured based on the semiconductor model). Therefore, it cannot be responsible for such a large scatter. If the dynamic surface emission center concept is employed, barium may be adsorbed on BaO, SrO or CaO, and the relative amount and adsorption position are different. Hence, the ability of each atomic aggregate to emit and transfer electrons is different. Moreover, each emission center is essentially independent. A large work function distribution may result due to the difference in the structure and nature of the aggregate.

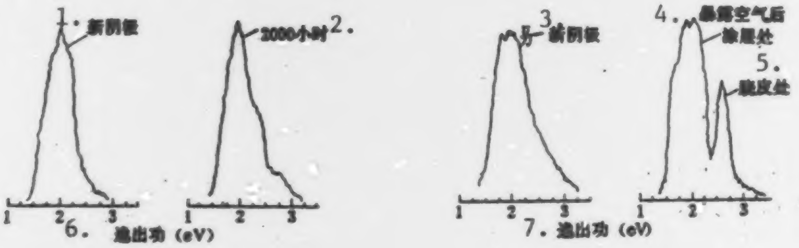

Figure 3. Distribution of Ternary Salt Work Function Measured with a Low Energy Scanning Electron Probe

[Key on following page]

Key:
1. New cathode
2. 2000 hours
3. Another new cathode
4. Coating after exposure to air
5. Peeled spot
6. Work function (eV)
7. Work function (eV)

In addition, there was one measured work function according to references [7,8]. This value is not the effective work function based on the measuring principle. If it indeed is the average, then there should not be a maximum and a minimum current. There are no extrema in polycrystalline metals. Therefore, the single crystal BaO on iridium system does not reflect the essence of a practical cathode. This point was discussed in the previous section from a different angle.

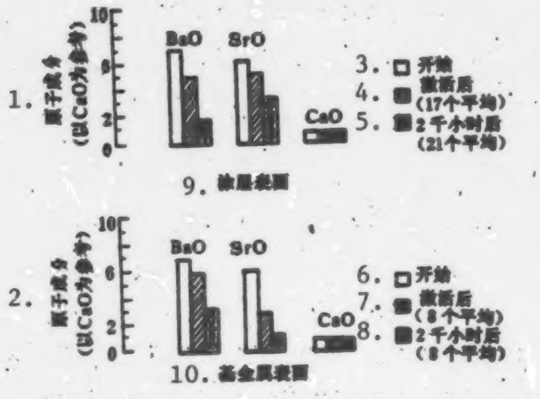

Figure 4. Variation of Alkaline Earth Metal Oxide at Coating Surface and Substrate Interface

Key:
1. Atomic Composition (relative to CaO)
2. Atomic Composition (relative to CaO)
3. Initial
4. Activated (average of 17)
5. After 2000 hours (average of 21)
6. Initial
7. Activated (average of 8)
8. After 2000 hours (average of 8)
9. Coating surface
10. Metal substrate surface

Because barium vaporizes easily relative to CaO, the composition of the ternary salt changes significantly in the life cycle. Figure 4 shows the changes in BaO and SrO relative to CaO. Active materials decreased at the surface as well as at the substrate interface. However, the emission characteristic of the cathode (i.e. the value of the effective work function ϕ) basically remains unchanged (see Table 1)[12]. Furthermore, the work function distribution does not vary by much after 2000 hours of life (see Table 3). According to the semiconductor model, the electron emission comes from donors in the bulk. However, the contribution from SrO and CaO was found to be far less than that of BaO in the single crystal study described above. Therefore, any change in the composition of the coating will result in a change in emissivity. After activation, the amount of BaO is decreased (see Figure 4), while the emissivity is increased. In the later stage in life, BaO is further decreased and there is little change in emission. These results cannot be explained by using the semiconductor model. If the dynamic surface emission center concept is employed, then thermal activation, which makes barium migration easier, will favor the formation of emission centers. In the life cycle, some centers are destroyed and other centers are created due to evaporization, poisoning and sputtering. These centers are localized and do not require a large amount of barium. Therefore, stable emission can be maintained even when the coating composition changes significantly.

Table 1. Variation of Composition, Preparation Technique and Work Function in a Life Cycle

	Cathode Preparation	Coating Properties				
		Alkaline Earth Metal Content (Atomic %)			O/O*	At 915K
		Ba	Sr	Ca		ϕ_e (eV)
New Cathode	1. 喷涂(6个平均)	44	49	7	0.97	1.84
	2. 印贴(5个平均)	44	48	8	0.99	1.84
	3. 印贴(2个平均)	41	49	10	1.06	1.86
	4. 印贴重激活(4个平均)	43	46	11	1.01	1.85
After 2000 hours	5. 印贴重激活(7个平均)	24	59	17	1.41	1.84
	6. 印贴重激活(19个平均)	29	55	16	1.43	1.84

Key:

1. Spray painted (average of 6)
2. Press-plasticized (average of 5)
3. Press-plasticized (average of 2)
4. Press-plasticized with reactivation (average of 4)
5. Press-plasticized with reactivation (average of 7)
6. Press-plasticized with reactivation (average of 19)

The variation of the oxygen content is another parameter which reflects the nature of the oxide cathode. In reference [12], the oxygen required to react with the alkaline earth metal was defined as 0*. The ratio of the actual measured oxygen content 0 to 0* is shown in Table 1. 0/0* is close to 1 regardless of the preparation technique, which is understandable. The 0/0* ratios at various parts of the cathode after 2000 hours are shown in Table 2. One can see that it is oxygen rich throughout the coating. But, the level of emission does not decrease. Therefore, the concept of oxygen vacancy donor in the bulk is not valid. Thus, the semiconductor model was invalidated. However, we cannot deny that excess barium has two high energy electrons which can emit to vacuum easily, all low work function, practical cathodes contain barium. This is a result of long term practice.[1,2]

Table 2. Ratio of Measured and Stoichiometric Oxygen Content at Different Parts of the Cathode (After 2000 Hours)

Position	Coating Surface	Sputtered 260Å	Peeled Coating (still with residue)	Base metallic substrate
0/0*	1.42	1.22	1.14	1.01

In reference [12], excess barium was defined by substracting the average amount of barium in the composition from the measured barium content. After 2000 hours of service, the distribution of elements in various parts of the cathode is shown in Figure 5. One can see that with the exception of the coating surface (1), which was used as the reference, other parts had excess barium. At the substrate surface and near the substrate, there were more excess barium (locations 4 and 5). Even at location 1, barium could still adsorb on SrO or CaO to form an emission center. Barium can migrate to a distant location, while Sr and Ca cannot. This suggests that the loss of barium might not be purely due to vaporization. There is also migration. This coincides with the activation concept in the dynamic surface emission center model. The activation of the cathode is not only happening in the initial high temperature treatment, it also occurs throughout the entire service life. Although the entire coating is oxygen rich, yet locally excess barium may still adsorb on the alkaline earth metal oxide aggregates. It is more probable to have such aggregates on the substrate surface. It is easier to get replenished after emitting electrons. Therefore, the metal surface bears more current. However, this does not mean that the coating is useless. It supplies excess barium and prevents gas poisoning and ion sputtering to protect the emission center.

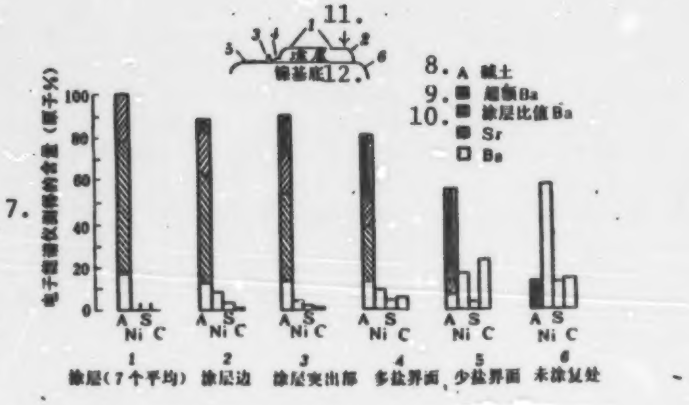

Figure 5. Contents of Various Elements in Different Parts of the Cathode After 2000 Hours

Key:

1. Coating (average of 7)
2. Coating edge
3. Protruding coating
4. High salt interface
5. Low salt interface
6. Uncoated area
7. Content measured by electron energy spectrometer (atomic %)
8. Alkaline earth
9. Excess Ba
10. Stoichiometric Ba content in the coating
11. Coating
12. Nickel substrate

V. Conclusions.

In summary, to demonstrate the accuracy of the semiconductor model, it is necessary to experimentally prove that (1) electrons indeed jump from donors in the bulk to the conduction band, (2) the electron concentration in the conduction band is sufficient to make the crystal electrically conductive, and (3) the emission current density is proportional to the square root of donor concentration. Unfortunately, such experiments did not materialize in several decades. In addition, many new phenomena unveiled by modern surface analysis techniques put this model in an even more difficult position. The dynamic surface emission center concept can better explain these new phenomena after summarizing the long term operating experience of hot cathodes. It seems to be a hopeful model.

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APPLIED SCIENCES

THEORY, CALCULATION OF LARGE SIGNAL CUT-OFF ZONE IBCFA

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol II, No 2, Mar 83 pp 45-51

[Article by Zhou Ping [0719 1627], Wu Boyu [0702 0130 3842], and Zhang Keqian [1728 0344 3383] of Department of Radio Electronics, Qinghua University: "Theory and Calculation of Large Signal Cut-off Injected Beam Cross Field Amplifiers (IPCFA)"]

[Text] Abstract: In a high gain injected beam cross field amplifier, the presence of a cut-off zone in the slow wave system is unavoidable. In this work, a physical model describing the drift process of a density modulated electron beam through the cut-off and the re-excitation of the slow wave by the high frequency field after the cut-off was introduced. The mathematical derivation and theoretical formulas are presented and a FORTRAN program was compiled. The results show that its error relative to experimental values is 7-20 percent. The length and position of the cut-off and the effect of electron drift in the cut-off on the power output were revealed by a series of calculations. The technique and program used in this work can be applied in CAD of IBCFA.

I. Introduction

We are well aware that it is impossible to totally eliminate reflected waves in a microwave tube. In order to cut off the feedback circuit and to suppress resonance, a cut-off zone must be installed in a high gain IBCFA (see Figure 1, P_{in} and P_{out} are the power input and output, E_d and B are the dc electric field and the magnetic induction intensity and d is the distance between the two electrodes).

The complex physical process in the cut-off zone has not been comprehensively discussed in the literature to date. Zhang Keqian[6] presented the formula for small signal thin electron beam in the cut-off zone. In the area of large signals, some authors did not take the cut-off zone into consideration in their theoretical calculations for IBCFA. Other authors[1,2] only considered a zero length cut-off and did not include the Diocotron effect in the cut-off zone, which caused some error in the final result. Yu[3] published a theoretical calculation technique for large signals in the Model M device. However, the actual calculation is not yet reported. Shu Shiwei [5289 0013 3956] et al[4] compiled an IBCFA program based on Yu's theory. However, it also did not involve the cut-off zone problem.

In the computer aided design (CAD) of IBCFA, it is significant to quantitatively study the length and position of the cut-off zone and the effect of electron drift in the cut-off zone on the properties of the tube. In this work, a comprehensive physical model is introduced. The drift process and the buildup of the high frequency field at the outlet of the cut-off zone were considered. Furthermore, on the basis of Shu's work, we compiled a computer program (in FORTRAN) for IBCFA including the cut-off zone to conduct calculations. Yu's model and formulas were used in the interaction region and the details are not repeated here.

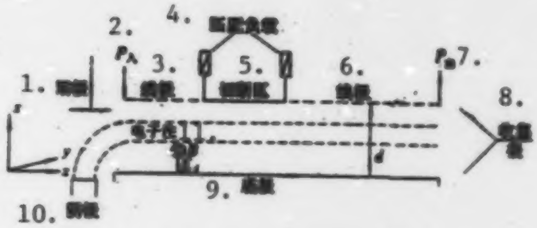


图1 IBCFA 器件结构示意图

Key:
1. anode
2. P_{in}
3. line
4. matching load
5. cut-off zone
6. line
7. P_{out}
8. collector
9. base
10. cathode
11. injected electron

Figure 1. Schematic Diagram of the Structure of an IBCFA

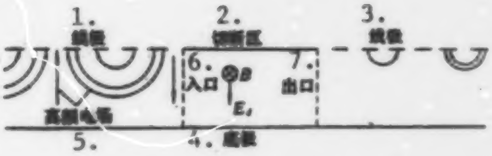


图2 切断区示意图

Key:
1. line
2. cut-off zone
3. line
4. base
5. high frequency electric field
6. entrance
7. outlet

Figure 2. Schematic Diagram of the Cut-off Zone

A cut-off zone is equivalent to a drift zone without any high frequency field (see Figure 2). Therefore, the physical process in the cut-off zone can be simplified as the following physical model.

Let us assume that the high frequency cutoff in the cut-off zone is zero and there are only dc electric field, dc magnetic field and space charge field in the cut-off zone. A high frequency current is induced in the slow wave structure after a density modulated electron beam drifting through the cut-off zone. It is excited by the high frequency field and continues to interact with the escaped electron beam to complete the energy exchange process. The amplitude and phase of the RF field are totally determined by the induced current on the slow wave line.

2. Electron Drift Process in the Cut-off Zone

Because the high frequency line is zero in the cut-off zone, only the space charge field and the dc electromagnetic field will affect the motion of electrons. All we have to do is to find the space charge field by letting the amplitude of the high frequency field in the cut-off zone equal to zero.

3. Calculation of Induction Current At the Cut-off Zone Outlet

The electron beam is density modulated in front of the cut-off zone. Therefore, it is distributed periodically. Let us assume that the period is λ_r and neglect minor variations between neighboring cycles, then the charge distribution can be decomposed into the sum of time harmonics as follows:

$$\rho(x',y',t)=\sum_{k=0}^{\infty}\left[{}_c\rho_x^{(K)}\cos(K\omega t-K\beta_\gamma y')-{}_s\rho_x^{(K)}\sin(K\omega t-K\beta_\gamma y')\right] \qquad (1)$$

where P(x', y', t) is the charge density at x', y' at time t, $cP_x^{(K)}$, and $sP_x^{(K)}$ are the Fourier transform coefficients of the space charge on the x' plane at t=0:

$${}_c\rho_x^{(K)}=\frac{2}{\lambda_\gamma}\int_0^{\lambda_\gamma}\rho(x',y',0)\cdot\cos K\beta_\gamma y'\,dy',\quad {}_s\rho_x^{(K)}=\frac{2}{\lambda_\gamma}\int_0^{\lambda_\gamma}\rho(x',y',0)\sin K\beta_\gamma y'\,dy',\quad \beta_\gamma\,(=2\pi/\lambda_\gamma)$$

is the phase constant of the γth space harmonic, ω is the angular frequency of the high frequency signal, x' and y' represent the coordinate in a static coordinate system which is related to a moving coordinate x, y (at a speed of ω/β_γ) as follows:

$$x'=x,\qquad y'=y+\int_0^t\frac{\omega}{\beta_\gamma(t)}dt=y+l \qquad (2)$$

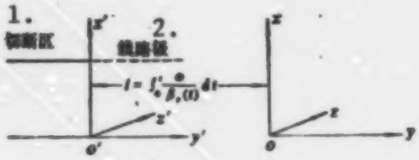
Let us assume that the origins of these two coordinates coincide at the exit of the cut-off zone at t=0 (see Figure 3).

According to the formula given by Rowe[2], if only the fundamental wave component of the charge distribution is considered, then the space charge $P^{(1)}$ is related to the induced charge $P_i^{(1)}$ according to the following:

$$\rho_i^{(1)}(y',t) = -h\int_0^d \Psi^{(1)}(x')\rho^{(1)}(x',y',t)dx' \tag{3}$$

$$\Psi^{(1)}(x') = \mathrm{sh}\beta_\gamma x'/\mathrm{sh}\beta_\gamma d \tag{4}$$

where h is the width of the electron beam in the z direction and the superscript "(1)" represents the fundamental wave component.



Key:
1. cut-off zone
2. line

图3 两种坐标系的关系

Figure 3. Relation Between the Two Coordinates

In a Model M cross field device, the x component of the electron velocity, v_x, is much smaller than the y component V_y. In addition, V_y is very close to the cold synchronous speed $v_{eo}=E_d/B$. Therefore, the electron velocity can be approximately considered as v_{eo} when we determine the induced current at the exit of the cut-off zone. Thus, the alternating fundamental wave component of the space convection-current density is:

$$J^{(1)}(x',y',t) = \rho^{(1)}(x',y',t)\cdot v_{eo} \tag{5}$$

The space charge moves in the y' direction at a speed of v_{eo}. The corresponding induced current should also flow at the same speed and the induced current alternating fundamental wave component is

$$
\begin{aligned}
I_i^{(1)}(y',t) &= \rho_i^{(1)}(y,t)\cdot v_{e0} \\
&= -hv_{e0}\int_0^d [{}_c\rho_x^{(1)}\cos(\omega t-\beta_\gamma y') - {}_s\rho_x^{(1)}\sin(\omega t-\beta_\gamma y')]\frac{\operatorname{sh}\beta_\gamma x'}{\operatorname{sh}\beta_\gamma d}dx' \\
&= -\frac{v_{e0}h}{\operatorname{sh}\beta_\gamma d}\rho_m\cos(\omega t-\beta_\gamma y'+\varphi) \qquad (6)
\end{aligned}
$$

where

$$\rho_m=\left\{\left[\int_0^d {}_c\rho_x^{(1)}(x')\operatorname{sh}\beta_\gamma x'\,dx'\right]^2+\left[\int_0^d {}_s\rho_x^{(1)}(x')\operatorname{sh}\beta_\gamma x'\,dx'\right]^2\right\}^{1/2} \qquad (7)$$

$$\varphi=\operatorname{arctg}\left[\int_0^d {}_s\rho_x^{(1)}(x')\operatorname{sh}\beta_\gamma x'\,dx'\Big/\int_0^d {}_c\rho_x^{(1)}(x')\operatorname{sh}\beta_\gamma x'\,dx'\right] \qquad (8)$$

In the moving coordinate system, the induced current $I_i^{(1)}$ becomes

$$I_i^{(1)}(y)=(-v_{e0}h/\operatorname{sh}\beta_\gamma d)\rho_m\cos(\beta_\gamma y-\varphi) \qquad (9)$$

In the coordinate moving at a speed of $\omega/\beta\gamma$, the high frequency field propagating on the slow wave line can be decomposed into the following space harmonic waves[3].

$$
\left.
\begin{aligned}
E_x^{(e)} &= \sum_{m=-\infty}^{\infty} A_m\frac{\operatorname{ch}\beta_m x}{\operatorname{sh}\beta_m d}\sin\left[\int_0^t \omega\left(1-\frac{\beta_m}{\beta_\gamma}\right)dt-\beta_m y\right] \\
E_y^{(e)} &= \sum_{m=-\infty}^{\infty} A_m\frac{\operatorname{sh}\beta_m x}{\operatorname{sh}\beta_m d}\cos\left[\int_0^t \omega\left(1-\frac{\beta_m}{\beta_\gamma}\right)dt-\beta_m y\right]
\end{aligned}
\right\} \qquad (10)
$$

We are concerned with the γth harmonic of the high frequency field which is capable of interfacing with the electron beam in synchronization. In the time harmonics of the induced current, only the fundamental conponent $I_i^{(1)}$ has the same frequency as the I harmonic, which is why it can be used in the excitation.

According to the equivalent circuit theory, when a high frequency current encounters a slow wave line with an impedance Z_r, the mean power transmitted on an equivalent line is $P=\frac{1}{2}\left|I_i^{(1)}\right|^2 Z_\gamma$. Because $Z_\gamma=A_\gamma^2/2\beta_\gamma^2 P$, the amplitude of the high frequency field excited by the induced current $I_i^{(1)}$ is $A_\gamma=|I_i^{(1)}|\cdot Z_\gamma\beta_\gamma$.

At the exit of the cut-off zone, there is not enough time for the field to interact with the charges. The initial high frequency field is determined by the induced current. Therefore, the RF field should be in phase with the induced current, i.e. the field should have the same initial phase angle "-φ".

$$\left.\begin{aligned} E_x^{(s')} &= -A_\gamma(\mathrm{ch}\beta_\gamma x/\mathrm{sh}\beta_\gamma d)\sin(\beta_\gamma y-\varphi) \\ E_y^{(s')} &= -A_\gamma(\mathrm{sh}\beta_\gamma x/\mathrm{sh}\beta_\gamma d)\cos(\beta_\gamma y-\varphi) \end{aligned}\right\} \qquad (11)$$

From the above formulas we can see that the phase of the newly excited high frequency field in the moving coordinate is shifted by an angle φ relative to that in front of the cut-off zone.

III. Analysis and Discussion of Calculated Results

We compiled a FORTRAN computer program based on the above theory and conducted calculations for two tubes with actual parameters. In the calculation, the electron beam was injected parallel to the entrance of the interacting region. The electron injection is divided into three layers and each layer consists of 128 charge rods. There are a total of 384 charge rods.

1. Comparison of Calculated and Experimental Results.

We calculated two cut-off zone injected beam cross field tubes: (1) the "K-31" tube developed by Qinghua University with a 102 mm long first gain section, 63 mm long cut-off zone, and 194.5 mm long second gain section; and (2) the "L-3974" tube developed abroad[5] with a 114 mm long first gain section, a 12.7 mm cut-off zone, and a 165.1 mm long second gain section. The operating parameters and calculated results are shown in Tables 1 and 2. In these tables, the symbols represent that: f is the frequency, Z_r is the coupled impedance, V_L is the line voltage, V_s is the base voltage, α_1 and α_2 are the attenuation coefficients of the first and second gain circuit, B is the dc magnetic field, I is the injected electron current, P_{in} is the power input, P_{out} is the power output, G is the power gain, η is the efficiency, $P_{out-cal}$ and $P_{out-exP}$ are the calculated and experimental power output data, respectively.

Table 1. Operating Parameters

管 1. 型	f(Hz)	Z_γ(Ω)	V_L(V)	V_S(V)	$\alpha_1'\left(\frac{dB}{m}\right)$	$\alpha_2'\left(\frac{dB}{m}\right)$	B(Wb)	I(A)	2. $P_入$(W)
K-31(13°-1)	f_1^*	12.4	7500	-5600	12.4	16.7	0.1425	0.5	10
K-31(12°-1)	f_2^*	11.2	7500	-5000	12.4	16.7	0.1368	0.5	10
L-3974	14.9×10^9	9	10500	-4300	11.8	11.8	0.2773	0.255	2

3. * f_1、f_2均为C波段频率。

Key: 1. tube type; 2. P_{in}(W); 3. f_1 and f_2 are c-band frequencies

Table 2. Comparison of Calculated and Experimental Results

管 1. 型	2. 实验数据			计算 3. 结果			4. 功率相对误差 $\left(\frac{P_{出计}-P_{出实}}{P_{出实}}\right)$
	5. $P_{出}$(W)	G(dB)	η	6. $P_{出}$(W)	G(dB)	η	
K-31(13°-1)	830	19.2	22.1%	998	19.99	26.6%	20.2%
K-31(12°-1)	600	17.8	16%	642	18.1	17.1%	7%
L-3974	500	24	18.7%	598	24.8	22.3%	19.6%

Key:
1. tube type
2. experimental data
3. calculated results
4. relative power error ($P_{out-cal}-P_{out-actual}/P_{out-actual}$)
5. P_{out}(W)
6. P_{out}(W)

From Table 2 we can see that the calculated results are slightly higher, which might be due to the determination of the attenuation coefficient α' of the circuit. Near the output end, electrons are captured by the line. In addition, the thermal consumption is also increased due to the high power frequency. These two factors cause the temperature on the line surface to rise, leading to higher resistance and increasing line attenuation coefficient α'. In our calculation, the value of α' used was measured at a colder temperature, and is smaller than the actual value. We conducted a series of comparison calculations for the L-3974 tube (the initial electron drift velocity is different from that listed in Table 2 for the L-3974 tube). When the cold measured value of α' is 11.8(dB/m), the power output is 320 W. If we assume that the average temperature on the line is 250°C, the calculated α' is 16.3 and the power output is 217 W. If the latter is correct, then the relative difference is 47%. Thus, the value of α' has a great impact on the power output.

In summary, the calculated values are close to the experimental ones. If the line attenuation coefficient α' is properly corrected, then the error will be even smaller. This indicates that the physical model is capable of describing major factors of the physical process in the sever. Our program is sufficiently accurate as an ancillary tool for the design of IBCFA devices to provide data to indicate the effect of various physical parameters.

2. Effect of Electron Drift on Power Output.

Curve 1 in Figure 4 represents a zero length of the cut-off zone, i.e. the high frequency field abruptly drops to 0 at 102 mm. A newly excited field due to induced current exists from that point onward. Curve 2 represents the situation in which the cut-off zone length is 63 mm. We can see that the un-saturated power of Curve 1 is always higher than that of Curve 2. This is because the second gain slow wave line of Curve 1 is 63 mm longer than that of Curve 2. When the tube length is fixed, the longer the cut-off zone is, the shorter the second gain section becomes, which does not favor an increased power output.

In real tubes it is impossible to have zero length of the cut-off zone. Curve 1 was moved laterally by 63 mm to obtain Curve 3. It is equivalent to the newly excited high frequency field at the actual exit of the sever by taking the length of the sever into account, but excluding the effect of the drift process (which is the treatment of Hull and Howe). From Figure 4 we can see that the un-saturated power output of Curve 3 is always lower than that of Curve 2. The difference at the output is nearly 300 W. This comparison clearly demonstrated that electron drift in the sever has a great effect on the power output. Because electron clusters are improved by the "Diocotron" effect, the interaction between escaped electrons and the field is more complete and intense. Results of this calculation show that it may be feasible to assume a zero length cut-off zone and to neglect electron drift when the cut-off zone is short. However, the error introduced into the power output cannot be neglected when the cut-off zone is long.

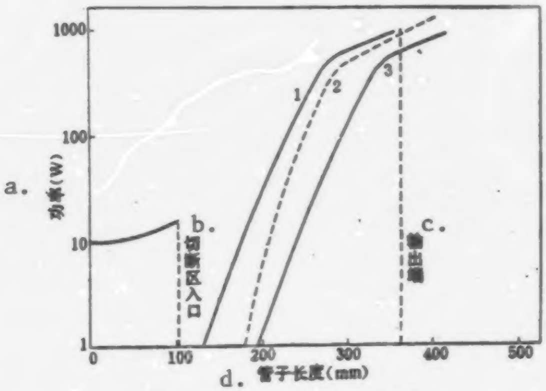


图4 切断区内电子漂移过程的影响

Figure 4. Effect of Electron Drift in the Cut-off Zone

Key:
- a. power (W)
- b. cut-off zone
- c. output end
- d. tube length (mm)

Figure 5 shows computer simulated electron cloud patterns of a K-31 (13#-1) tube, which illustrate the electron clusters in the tube and the field - charge interaction process. Each electron cloud pattern is an electron distribution of a monitored slow wavelength λ_r at a specific time. "T" represents the time lapse after electrons are injected (in units of spin period T_C). The Arabic numbers shown in the interaction region represent the charge rod at that point (a total of 384 rods in the calculation).

Before entering the cut-off zone (T=12), the electron cluster is very weak. It is still possible to find traces of three parallel laminar, but non-uniform layers (to simplify the calculation, we assumed that electrons were injected in three uniform parallel laminar layers). This suggests that there is some kind of density modulation. After drifting into the cut-off zone, electron clusters begin to take shape at the exit of the cut-off zone (T=24). As electrons continue to interact with the field, the clustering of electrons and the high frequency field continue to intensify. Electrons are clustered together in the repulsive field (T=48), and its position is rising. The potential energy of the electrons is converted into RF energy (output end, T=54), until most of the electrons have struck the line and the RF power is reaching a saturation (T=60).

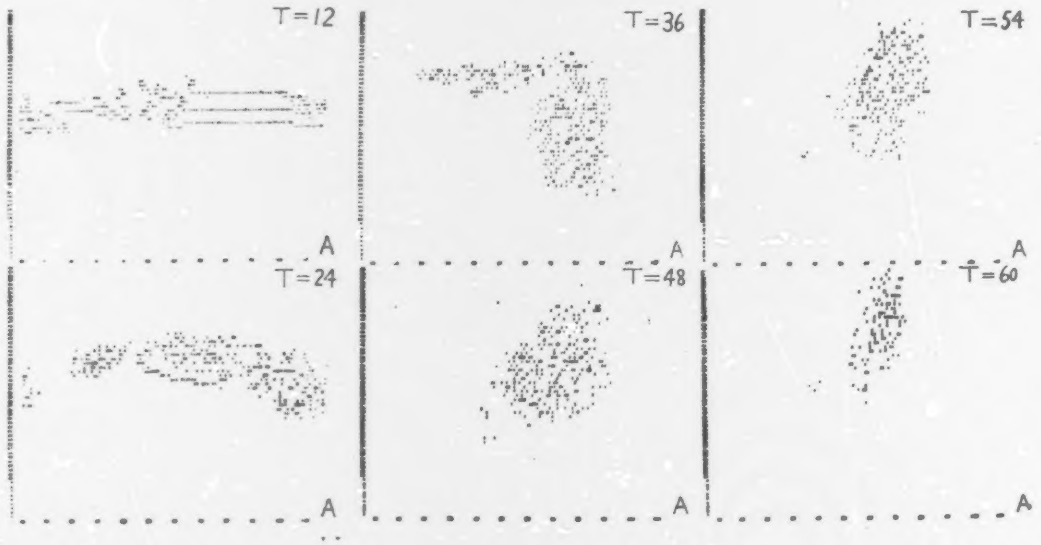


Figure 5. Computer Simulated Electron Cloud Pattern

3. Effect of Cut-off Zone Length.

Figure 6 shows the comparison of calculated results based on different cut-off length. The cut-off zone length is 63 mm for Curve 2, and 126 mm for Curve 4. Again, it indicates that when the total tube length is fixed, the longer the cut-off region is the lower the power output is.

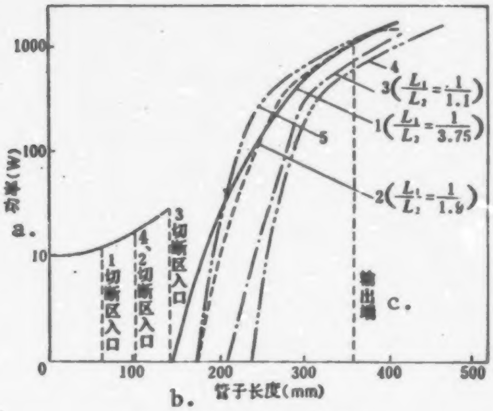


图 6 切断区长度和位置的影响

Figure 6. Effect of Tube Length and Sever Location

Key:

1. }
4,2. } cut-off zone entrance
3. }
a. power (W)
b. tube length (mm)
c. output end

Curve 5 was obtained by shifting Curve 4 laterally by 63 mm. Compared to Curve 2, we can see that the interaction beyond the cut-off zone is different. The un-saturated power output of Curve 5 is higher than that of Curve 2, which demonstrates that the longer the cut-off zone is, the more obvious the Diocotron effect on the electron cluster is. At least, this is true for a cut-off zone length up to 120 mm. As for a longer cut-off zone, we did not further calculate whether the Diocotron effect still favors the clustering of electrons.

4. Effect of Cut-off Zone Position.

The position of the cut-off zone is one of the problems of most concern in the design of high gain IBCFA devices. Figure 6 shows the comparison of calculated results obtained with a 63 mm long K-31 tube with its sever at different positions. Let the first gain length be L_1 and the second gain beyond the cut-off zone be L_2, then Curve 3 represents $L_1/L_2=1/1.1$ and $L_1=141.6$ mm. Curve 2 represents $L_1/L_2=1/1.9$ and $L_1=102$ mm. Curve 1 represents $L_1/L_2=1/3.75$ and $L_1=62.4$ mm.

From Figure 6 we can see that the power output of Curve 3 is always lower than those of Curves 1 and 2. This shows that it does not favor the power output if the sever is located in the middle of the tube ($L_1/L_2=1$). The reason is very simple. The second gain section is too short to make a significant gain at the high frequency power output end.

Curves 1 and 2 basically coincide with each other in the 300 mm-400 mm range, which indicates that when the output end is located in this region, the cut-off zone entrance may be placed anywhere between 62.4 mm-102 mm without affecting the power output. If the output end is at 300 mm and L_1=102 mm, then $L_1/L_2=1/1.3$. If the output end is at 400 mm and L_1=62.4 mm, then $L_1/L_2=1/4.4$. To meet the requirements in power output and self-excited oscillation, it is more appropriate to have the sever placed at $L_1/L_2=1/1.5 - 1/2.5$ in a K-31 tube. The design of K-31 adopted $L_1/L_2=1.9$, which proves that the design is correct.

In addition, we can also see from the three calculated curves (1, 2 and 3) in Figure 6 that the high frequency power output is not yet saturated at 359.5 mm. From the cloud pattern at T=54 in Figure 5 that there are considerable electron clusters at the output end. If the output end is moved back 50-60 mm, a saturated power output may be attained. The electron cloud pattern at T=60 in Figure 5 also illustrates this point.

IV. Conclusions

1. The theoretical calculation is in good agreement with the experimental data, which shows that the physical model and mathematical description are essentially accurate.

2. The electron drift process in the cut-off zone has a significant effect on the clustering of electrons and the power output of the tube. This must be considered, especially when the sever is long.

3. When the total length of the tube is fixed, the insertion of a cut-off zone will shorten the slow wave line in the second gain section, which does not favor increased power output. Therefore, the cut-off length should be reduced as much as possible if isolation can be ensured.

4. The method can quantitatively investigate the effect of the position of the cut-off zone on the performance of the tube. Results indicate that the output of the K-31 tube may be moved backward by 50-60 mm if the position of the sever is properly designed.

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APPLIED SCIENCES

NEW PLA, ITS OPTIMIZATION ALGORITHM FOR COMPUTER-AIDED DESIGN*

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 11 No 4, Jul 83 pp 52-60

[Article by Liu Chunhe [0491 2504 0735] of Harbin Institute of Technology]

[Text] Abstract: This paper presents a new type of PLA (R-PLA) which is made up of AND-EXCLUSIVE-OR arrays. The multi-channel digital networks described by vector Boolean algebra and the adders with parity check and parity prediction are realized very conveniently by using the R-PLA. The R-PLA is also simple for generating test codes of Boolean difference. This paper provides CAD algorithms for finding optimal or near-optimal ring sum cover.

I. Introduction

Hitherto, the ROM (read-only memory) and PLA (programmable logic array) in use were all made up of "AND-OR" array modules, so the implemented functions are the sum of products. The implemented functions just happen to be the sum with the least implications. This paper presents a new type of PLA module which is stronger in capability, and its internal structure is an "AND-EXCLUSIVE-OR" array. Since the operations of summing rings (EXCLUSIVE-OR) are more agile with the functional variations, the reflection of the functional change rate is more clear, consequently, they have attracted early attention of the specialists. The appearance of LSI and VLSI have enabled people to use vector Boolean algebra to describe the large scale multi-channel digital system network[4], and this paper shows that this type of PLA is the most convenient module for its implementation. An example from reference [4] shows its expression as below and its real value as in Table 1:

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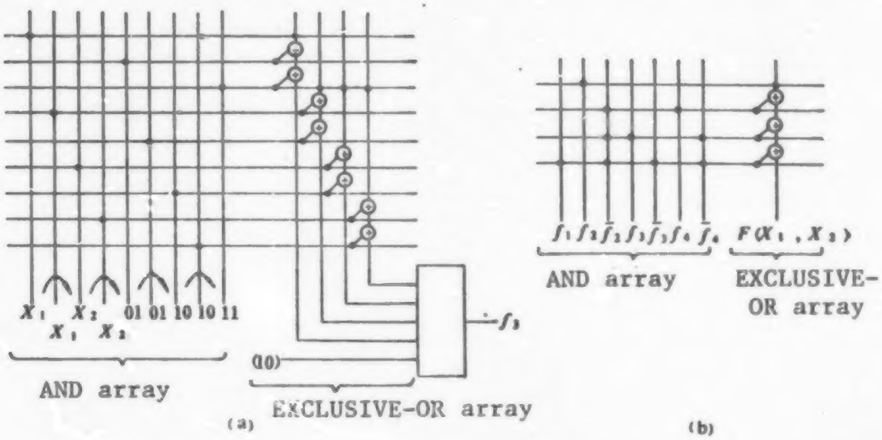
* Paper received Jul 82, finalized Feb 83 [d. 11 Mar 83]

$$F(X_1,X_2)=(01)X_1^{00}(\widetilde{X_1^{00}})X_2^{00}(\widetilde{X_2^{00}})+(11)X_1^{00}(\widetilde{X_1^{00}})X_2^{01}(\widetilde{X_2^{01}})$$
$$+(10)X_1^{01}(\widetilde{X_1^{01}})X_2^{10}(\widetilde{X_2^{10}})+(01)X_1^{10}(\widetilde{X_1^{10}})X_2^{11}(\widetilde{X_2^{11}})$$
$$=f_1+f_2+f_3+f_4$$
$$=f_2\oplus\bar f_2 f_4\oplus\bar f_2 f_3\bar f_4\oplus f_1\bar f_2\bar f_3\bar f_4$$

where $f_1=(01)X_1^{00}(\widetilde{X_1^{00}})X_2^{00}(\widetilde{X_2^{00}})$, $f_2=(11)X_1^{00}(\widetilde{X_1^{00}})X_2^{01}(\widetilde{X_2^{01}})$, $f_3=(01)X_1^{01}(\widetilde{X_1^{01}})X_2^{10}(\widetilde{X_2^{10}})$, $f_4=(01)X_1^{10}(\widetilde{X_1^{10}})X_2^{11}(\widetilde{X_2^{11}})$, where $X^P=X\oplus\bar P$, $P=(P_1,P_2,\cdots P_n)^*$, $\widetilde{X^P}$ is the rotation vector



X_1
X_2
$\bar X_1$
$\bar X_2$
01 01 10 10 11
(10)
f_3
AND array
EXCLUSIVE-OR array
(a)
$f_1\ f_2\ \bar f_2\ f_3\ \bar f_3\ f_4\ \bar f_4$
$F(X_1, X_2)$
AND array
EXCLUSIVE-OR array
(b)

Fig. 1 $F(X_1,X_2)$ implemented by R-PLA

(a) f_3 (b) $F(X_1, X_2)$ (↷ indicates rotation)

* n = 2 in this example.

Table 1. Real Values of Vector Boolean Functions

X_1	X_2	F
0 0	0 0	0 1
0 0	0 1	1 1
0 1	1 0	1 0
1 0	1 1	0 1
others		0 0

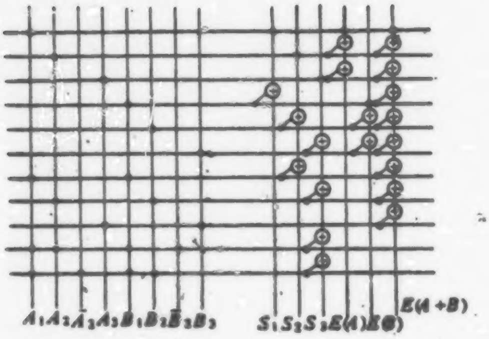


Fig. 2 Tri-bit Half-adder

Figure 1 shows the logic array diagram of the new type of PLA implementation presented in this paper. The figure shows only the vector expressions of f_3 (Fig. 1(a)) and $F(X_1, X_2)$ (Fig. 1(b)). Since this module is an expression of the ring sum implementation, it is called the R-PLA (ring programmable logic array).

With the R-PLA module it is very easy to implement the half-adder with parity-predicting fault tolerance capability. As shown in the tri-bit half-adder example in Fig.2, $A = (A_1A_2A_3)$ and $B = (B_1B_2B_3)$ are respectively the addend and augend, S_i is the i-th bit sum, and $E(X)$ is the parity of X.

II. Ring Sum Optimization Theory

Usually we define the 2^n states of the n variables of the combined function $f\ (x_1, x_2\ \ldots,\ x_n)$ as an n-dimensional Boolean solid B_2n, so f expresses the sum of the products, i.e., the sum of the implication terms which collectively provide the covering for the 1-points of f on B_2n (and indeterminate points), and each implication term is a cube on B_2n. When f expresses the ring sum of the Reed-Muller expansion, it is indeed the new mapping relation. Therefore, the functional minimization theories of the past need to be suitably modified, and the mapping relationships amongst them need to be studied, and there is a need to set up some new concepts.

A Reed-Muller expansion of n variables has 2^n terms, let 1 be all its expansion coefficients, then the 2^n product terms (the constant term is called the term whose product is fixed at 1), form a collection of 2^n states. We define these 2^n states as an n-dimensional ring solid, designated as R_2n. We consider the mapping from Boolean solid B_2n to ring solid R_2n:

$$\varphi: \ B_{2^n} \longrightarrow R_{2^n}$$

it is not hard to infer that

$$\varphi = \varphi \begin{pmatrix} 0 \longrightarrow \times \\ 1 \longrightarrow 1 \\ \times \longrightarrow 0 \end{pmatrix}$$

where 0 designates complement, 1 indicates the source variable, and X indicates that its variable is missing.

For example, a mapping relationship for 3-dimensional solids is shown in Figure 3.

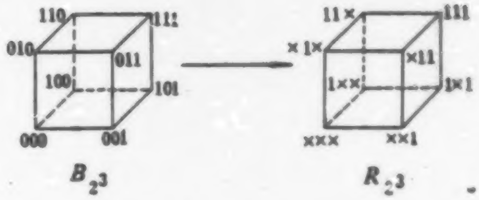


Fig. 3 The Mapping Between 3-dimensional Solids

Definition 1. The product of n variables is the smallest term, if and only if that product term is a point on R_2n, designated as E_i, where i is the sum of the powers of "1" in E_i.

For example, $x_1x_4x_5$ = (1xx11), we set the power of the j-th variable of a product term of n variables to be 2^{n-j}, as the smallest ring term is $E_k = (a_1a_2\ldots a_n)$, $a_i \in \{1, x\}$, then for

$$E_k=(a_1a_2\cdots a_n),\ a_i\in\{1,\times\}$$
$$k=a_1\cdot 2^{n-1}+a_2\cdot 2^{n-2}+\cdots+a_n\cdot 2^0$$

and where

$$a_i\cdot 2^{n-i}=\begin{cases}0 & ,\text{if } a_i=\times\\ 2^{n-i} & ,\text{if } a_i=1\end{cases}$$

then $x_1x_4x_5 = E_{19}$.

The 1-point of function f is defined as the "1" product term of the coefficients of the Reed-Muller expansion on R_2n. Conversely, the 0-point of f is the "0" product term of the coefficients in the Reed-Muller expansion. A point is called an odd-order point (whether it is a 1-point or a 0-point) when it is covered by an odd number of product terms, similarly, a point is called an even-order point if it is covered by an even number of product terms. Then, the so-called 1-point or 0-point, without any special explanation, speak of the odd order number. We know from Definition 1, the Reed-Muller expansion is the sum of rings of f (ring sum) of the smallest terms of function f.

Definition 2. By a simplest ring and its expression we mean: (1) the total number of variables in the expression is the least, and (2) there are the least number of operation symbols and rings in the expression. The numbers of the variables and operation symbols are called respectively the values of the ring and expression.

The function f(x) has changed from the sum of products into the ring sum, and for the standard type of functions, clearly

$$f(x)=\sum_{i\in I_1} m_i=\bigoplus_{i\in I_1} m_i$$

where m_1 is the smallest term of B_2n, I_1 is also the sample set of 1-points in B_2n, and $\bigoplus$ is the ring sum $\oplus$.

For the form of the set of the largest terms of f, we have

$$f(x)=\prod_{i\in I_0} M_i=\bigoplus_{i\in I_1} m_i\oplus 1$$

where I_o is the sample set of 0-points of B_2n.

For the more common conditions, there are the following theorems, but first we consider the next definition:

Definition 3. Let n be the power of ring of n variables

$$X^e=x_1^{e_1}\cdot x_2^{e_2}\cdots\cdots x_n^{e_n}$$

where $x_i^{e_i}=x_i+\bar{e}_i$, $e_i\in\{0,1\}$, $e=(e_1,e_2\cdots\cdots,e_n)$.

Theorem 1. If function $f(x) = \sum_{i=1}^{m} P_i$, P_i is the product term, then the formula of its ring sum is $f(x)=\bigoplus_{e} P^e$, $0<e\leqslant 2^m-1$

where $P=(P_1,P_2,\cdots,P_m)=\prod P_i$.

Proof. It is obvious, using mathematical induction.

Definition 4. The intersection of two ring product terms $P_i=(a_{i1}a_{i2}\cdots a_{in})$ and $P_j=(b_{j1}\ b_{j2}\cdots b_{jn})$ is

$$P_i\cap P_j=\begin{cases} 0 \text{ if there is a k, such that } a_{ik}\cap b_{jk}=\phi, \\ \{(a_{i1}\cap b_{j1})(a_{i2}\cap b_{j2})\cdots(a_{in}\cap b_{jn})\} \quad \text{others} \end{cases}$$

where the operator $\cap$ satisfies Table 2.

Table 2 $\cap$ table

$\cap$		b_{jk}		
		0	1	×
a_{ik}	0	0	1	×
	1	1	1	ϕ
	×	×	ϕ	×

Table 3 δ table

δ		b_{jk}		
		0	1	×
a_{ik}	0	0	×	1
	1	×	1	0
	×	1	0	×

Table 4 d table

d		b_{jk}		
		0	1	×
a_{ik}	0	ϕ	×	1
	1	ϕ	ϕ	Ω
	×	ϕ	Ω	ϕ

(0 means null)

Definition 5. The δ-operation of two ring product terms $P_i=(a_{i1}\ a_{i2}\cdots a_{in})$ and $P_j=(b_{j1}\ b_{j2}\cdots b_{jn})$ is

$$P_i\delta P_j=\begin{cases}\{a_{i1}\ a_{i2}\cdots a_{ik-1}(a_{ik}\ \delta\ b_{jk})a_{ik+1}\cdots a_{in}\} \\ \qquad \text{when there is only one k such that } a_{ik}\neq b_{jk}; \\ P_j \text{ other conditions}\end{cases}$$

where the operator δ satisfies Table 3.

For example,

$P_i=(1101\times\times)$, $P_j=(\times101\times\times)$, then $P_i\delta P_j=(1101\times\times)\ \delta\ (\times101\times\times)=(0101\times\times)$, but $P_i\cap P_j=\phi$ (since when $k=1$, $1\cap\times=\phi$).

Definition 6. The d-operation of two ring product terms $P_i=(a_{i1}\ a_{i2}\cdots a_{in})$ and $P_j=(b_{j1}\ b_{j2}\cdots b_{jn})$ is

$$P_i dP_j=\begin{cases}P_i \text{ when there a k such that } a_{ik}db_{jk}=\Omega; \\ \phi \text{ for all k, such that } a_{ik}db_{jk}=\phi; \\ \{a_{i1}a_{i2}\cdots a_{ik-1}e_{ik}a_{ik+1}\cdots a_{in}/ \text{ such that there is only one k,} \\ \text{such that } a_{ik}=0, \text{ and } b_{jk}\neq 0\}; \\ \bigcup_k\{a_{i1}\ a_{i2}\cdots a_{is-1}\ b_{js}\ a_{is+1}\cdots a_{ik-1}e_{ik}a_{ik+1}\cdots a_{in}| \text{ such that when there are} \\ \text{some S such that } a_{is}db_{js}=1 \text{ or when X, there is a k such that} \\ a_{ik}=0 \text{ and } b_{jk}\neq 0\}\end{cases}$$

where the operation symbol d satisfies Table 4. In Table 4, $a_{ik}\ d\ b_{jk}=e_{ik}$; $e_{ik}\in\{1,x\}$, and Ω are non-intersecting, and ϕ is null.

For example, P_i=(100 x 10), P_j = (00 xx 11)
when k = 1, 1d0 = ϕ; when k = 2, 0d0 = ϕ;
when k = 3, 0dX = 1, then $\{101 \mathrm{X} 11\}$.
When k = 4, XdX = ϕ, when k = 5, 1d1 = ϕ,
when k = 6, 0d1 = X, then $\{10 \mathrm{XX} 1 \mathrm{X}\}$. So, $P_i d P_j = \{101\times 11,\ 10\times\times 1\times\}$.

From the aforementioned definition, the following basic properties can be inferred:

1. If $P_i \cap P_j = \phi$ and $P_i\ \delta\ P_j = P_k$, then $P_i\ d\ P_k = \phi$, $P_j\ d\ P_k = \phi$,
2. If $P_i \cap P_j \neq \phi$, and $P_i\ \delta\ P_j = P_k$ and $P_i\ d\ P_j = \phi$, then $P_k\ d\ P_j = \phi$,
3. If $P_i\ \delta\ P_j = P_k$ and $P_i \cap P_j \neq \phi$, then $P_i\ d\ P_j = P_k$,
4. $P_i \cap (P_j\ \delta\ P_k) = (P_i \cap P_j)\ \delta\ (P_i \cap P_k)$.

Definition 7. Ring product term P_j includes P_i, designated as $P_j \subseteq P_i$, if and only if P_j d P_i = ϕ, if i $\neq$ j then it is a true inclusion, designated as $P_j \subset P_i$.

Definition 8. There exists 2^{n-i} different points on R_{2^n} that may form a ringlet solid $T(2^{n-i})$ if and only if there are i identical variables in these 2^{n-i} points, where i $\in \{0,1,2,\ldots,n\}$, and especially when i=0, $T(2^n)$ = R_2n; and when i=n, $T(2^0)$=E.

According to Definition 8, it is clear that, on R_2n, the dimension number of a solid is n-i, and according to Definition 5, each ringlet solid is a ring product term. Therefore, the number of "0" belonging to that product term is equal to the dimension number of its ringlet solid, and, furthermore, we can infer that for a m-dimensional solid $P_m \in R_{2^n}$, covering 2^m points, and P_m has at least m variables.

Definition 9. In a ringlet solid P_i, if the smallest term E_j is the largest vertex of P_i if and only if E_j is the largest point of the angular coordinate j covered by P_i. Similarly, there is a smallest vertex in P_i.

Lemma 1. On R_2n, the number of variables belonging to the sub-solid P_i is equal to the number of variables of the largest vertex of P_i.

Proof: Let E_j be the largest vertex of P_i, and $C(P_i)$ and $C(E_j)$ be respectively the values (the number of variables) of P_i and E_j.
First, consider P_i covering two points (2 points), then $P_i = E_j\ \delta\ E_k$.

Then if $C(P_i) > C(E_j)$, then E_j has at least one digit with an "X," and the corresponding digit of E_k is "1," then

Since E_j and E_k are neighboring points (with only one different point), then $C(E_j) < C(E_k)$, and this contradicts E_j being the largest point. If $C(P_i) < C(E_j)$, then $(1 \in E_j)\ \delta\ (X \in E_k) = (X \in P_i)$, and this contradicts the δ-operation. Next, consider P_i covering 2^2 points, and let P_n, P_s be two solids, without loss of generality, let P_r cover E_j, then from the foregoing proof we know that $C(P_r)=C(E_j)$, and if $P_r \delta P_s = P_i$, then,

$C(P_i) < C(P_r)$, with the following two possibilities:

(1) $(1 \in P_r)\ \delta\ (\phi \in P_s) = (X \in P_i)$, then $P_r \subset P_s$ and P_r, and P_s all contradict the 1-dimensionality hypothesis;

(2) $(0 \in P_r)\ \delta\ (1 \in P_s) = (X \in P_i)$, then $P_s \subset P_r$ and P_r and P_s all contradict the 1-dimensionality hypothesis.

Similarly we can infer up to 2_m points, Q.E.D.

Definition 10. On R_2n, if the product term P_i does not cover any odd degree 0-points and covering at least one odd degree 1-points then P_i is a ring implication term. If a product term P_i covers only even degree 0-points and not covering any odd degree 1-point, then it is an auxiliary term.

Definition 11. On R_2n, if P_i is an auxiliary implication term, then P_i is an auxilary implication term if and only if for any selected auxiliary implication term P_j, $P_j d P_j \neq \phi$ and $P_i d P_j \neq \phi$. P_i can be called an auxiliary term for short.

Definition 12. On R_2n, if P_i is an implication term, then P_i is a ring implication term if and only if under a certain selected covering no ring implication term P_j can be found, $j \neq i$, and without the condition of increasing any auxiliary implication terms, there is $P_i d P_j = \phi$.

For the same function f, if it can form different sets of ring implication terms under different covering conditions, will form a family of sets of ring implication terms. We give two covering selections of the same function in the following, as shown in Figure 4. In the selection of Figure f(a),

$P_1 = (\times 100) = x_2\bar{x}_3\bar{x}_4$, $P_2 = (0\times 00) = \bar{x}_1\bar{x}_3\bar{x}_4$ are both ring implication terms;

$P_3 = (X01X) = \bar{x}_2 x_3$, $P_4 = (0XXX) = \bar{x}_1$ are both auxiliary implication terms; $P_5 = (XX01) = \bar{x}_3 x_4$ is a ring implication term; and $P_6 = (XXXX) = 1$ is an auxiliary implication term.

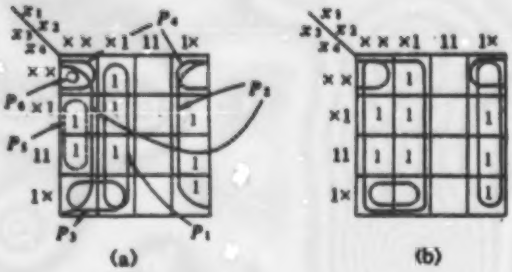


Fig. 4 Two Covering Selections

Lemma 2. If P_i is a ring implication term, then P_i has a number of variables no greater than the sum of the ring implication terms covered by P_i.

Proof. It comes naturally, following Lemma 1.

Lemma 3. In the family of sets of the ring implication terms of function f, the set with the least of the largest vertice is the optimal covering selection of the f-related operation symbol.

Proof. Obvious.

Theorem 2. In the family of sets of ring implication terms of function f, if S is the selection with the smallest number of variables, then S is also the least selection of operation symbol.

Proof. As S is the least selection of number of variables, there are three conditions:

(1) All of the largest vertices of S are 1-points (odd degree 1-point): If the largest vertices are not the smallest numbers, there will be at least one largest vertex which can be covered by the ring implication terms generated by another largest vertex. Also, as each largest vertex is a 1-point, there cannot be a point with larger value than the largest vertex of S, thus the number of the largest vertices can be decreased, hence violating the original assumption.

(2) All of the largest vertices are even degree 0-points: Since the values of these even degree 0-points are all greater than those other 1-points of the same ring implication terms, and, also, since the sum of the values of these even degree 0-points is the least, so, clearly, the number of the largest vertices is the least.

(3) There are odd degree 1-points and even degree 0-points in the largest vertices of S, then, by the synthesis of the two aforementioned conditions, the number of the largest vertices is the least. Q.E.D.

For a given function f, if we do not seek a complete family of sets of ring implication terms, but can directly find the smallest ring sum covering, it is still difficult to do this with computer-aided design (logic synthesis) under current conditions. However, we present a partition method in the following which may conveniently and easily find the quasi-smallest ring sum covering. Sometime, the obtained result is indeed the smallest ring sum covering.

Definition 13. On R_2n, if P_i is a ring implication term, if P_i is a partitioning term of the ring implication term (called the partitioning term for short) if and only if (1) P_i does not cover any 0-points; (2) any odd degree 1-point covered by P_i is not again covered by any other ring implication terms; and (3) $P_i dP_j \neq \emptyset$ for any ring implication terms not covering any 0-points.

For clarification, we take the function shown in Figure 4 and use the partitioning term to express it, as shown in Figure 5. We express function f as the ring sum of the partitioned terms, and this method is the partitioning method. The optimal partitioning is the one which obtain the least value of the function.

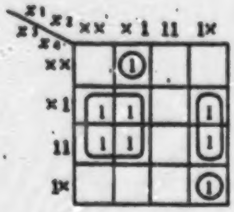


Fig. 5 Partitioning term of f

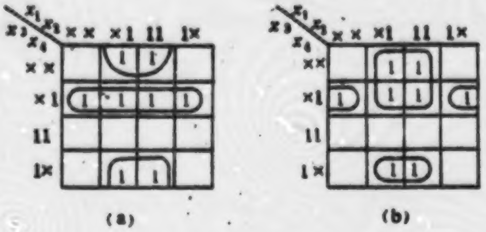


Fig. 6 Partitioning selection

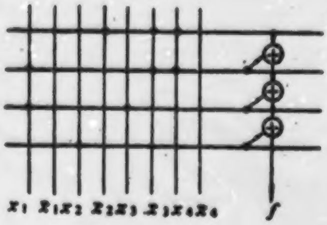


Fig. 7 R-PLA circuit of $f(x_1,x_2,x_3,x_4)$

Definition 14. In the 1-point set of f, the points which are not covered by the ring implication terms called scattered points, the greatest scattered point is the one with greatest number of variables.

Treating the conclusions of Theorem 2 with the partitioning method, we have the following theorem.

Theorem 3. For function f, the partitioning covering selection of the least number of variables is also the best partitioning covering selection of the operation symbol.

In order to find the covering selection of the least number of variables, we present the following partitioning methods.

Method 1.

(1) First, take each direction of the greatest scattered point to form a partitioning selection;

(2) Repeat step (1) for each largest scattered point;

(3) Form a complete family of sets of partitioning covering, make the selection among the one with the smallest number of variables.

Example: $f(x_1, x_2, x_3, x_4) = \sum_{1-8}(E_1, E_4, E_5, E_6, E_7, E_{12}, E_{13}, E_{14})$.

The starting greatest scattered points are E_{14}, E_{13}, take either one, say E_{14}, to find a partitioning covering selection as shown in Figure 6(a), and E_{13} has only one direction to find the partitioning term. Then use E_{13} to find the partitioning term. E_{13} has two directions in which to find the partitioning term, one of which has the same direction to set the partitioning selection as in Figure 6(a), and the other as shown in Figure 6(b). Other covering selections obtained through the greatest scattered points are the same as those in Figure 6(a) and 6(b). So, the final partitioning covering family of sets are

$$\{\{010\times,\ 00\times1\},\ \{01\times0,\ 011\times, 0\times\times1\}\},$$

Clearly, (a) given the best partitioning, since the sum of its variables is 6, and its total of symbols is 1, as $f(x_1, x_2, x_3, x_4) = \bar{x}_1 x_2 \bar{x}_3 \oplus \bar{x}_1 \bar{x}_2 x_4$.

However, as the ordinal initial functions are obtained from the truth tables, so, the form of the function as the sum of the smallest terms, clearly, Method 1 cannot be directly used; the smallest terms need to be converted into the smallest ring term. The following gives a function expressible as the sum of arbitrary product terms (including smallest terms), to find its optimal or near optimal computer-aided design (logic synthesis) of partitioning computation method.

Method 2

(1) Convert the product terms of the form of the product sum of the function into the ring product terms, this forms the set Z of product terms;

(2) Complete the δ-operation of any two product terms which are δ-operable, then designate by symbol ($\vee$), until those product terms without the $\vee$ symbol cannot be operated on by the δ-operation;

(3) Mutually carry out d-operations on any two product terms (including the results of their operations), then designate by $\not\vee$, until those product terms without the $\not\vee$ symbol cannot be operated by d-operation. Those product terms without $\not\vee$ symbol are members of the set of the smallest or quasi-smallest partitioning terms.

Example. The set of smallest terms of f(x_1, x_2, x_3, x_4) is

$$Z=\{0\overset{\vee}{1}00,\ 1100,\ 0001,\ 0\overset{\vee}{1}01,\ 0\overset{\vee}{1}11,\ 1\overset{\vee}{0}11,\ 0\overset{\vee}{1}10, 1\overset{\vee}{0}10\}$$

1. Carry out δ-operations on Z:

$$(0100)\delta(0101)=(010\times)$$
$$(0111)\delta(0110)=(011\times)$$
$$(1011)\delta(1010)=(101\times)$$

combining the results of those without V symbol and δ-operation, this form a new set

$$Z'=\{1\overset{\not\vee}{1}00,\ 0\overset{\not\vee}{0}01,\ 0\overset{\not\vee}{1}0\times, 0\overset{\not\vee}{1}1\times,\ 1\overset{\not\vee}{0}1\times\}$$

2. Carry out d-operations on Z":

$$(1100)d(0001)=\{1\overset{\not\vee}{1}0\times\}$$
$$(0001)d(1100)=\{\times001, 1\times01\}$$
$$(010\times)d(011\times)=\{01\overset{\not\vee}{\times}\times\}$$
$$(011\times)d(010\times)=\{\phi\},\ \text{likewise}$$
$$(110\times)d(101\times)=\{11\overset{\not\vee}{\times}\times\}$$
$$(101\times)d(110\times)=\{1\times1\times\}$$
$$(01\times\times)d(11\times\times)=\{\times1\times\times\}$$

so $\{\times001, 1\times01, 1\times1\times, \times1\times\times\}$ is the optimal partitioning cover for f(x_1, x_2, x_3, x_4), the implementing wiring is as shown in Figure 7.

According to the concepts introduced above, other algorithms can be deduced. Due to the limitation of space, they are not discussed.

III. Conclusions

This "AND-EXCLUSIVE-OR" array type of modules possess very strong capabilities. Besides implementing the large scale multi-channel digital system networks and implementing very strong capabilities of parity check or parity prediction, etc., fault tolerance technoques, they can also be conveniently implemented in the arithmetic or control units of computers. Consequently, this new type of PLA has a bright future implementing standardization and normalization of computer devices. Specifically, this new type of PLA has another strength, it makes the generation of error diagnostic test code much easier.

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ACCURATE COMPUTER-AIDED DESIGN OF MMIC BROAD-BAND FET AMPLIFIERS*

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 11 No 4, Jul 83 pp 76-84]

[Article by Wu Yongshi [0702 6102 6108] of Tianjin University, and Herbert J. Carlin of Cornell University, USA]

[Text] Abstract: A computer-aided design procedure applicable to low-noise and broad-band MMIC FET, amplifiers is presented. The method takes into account the non-unilateral behavior of the FET, losses in the matching networks and complex termination mismatches. The design procedure is more complete and accurate than currently available CAD methods. Two design examples, an 8 ~12 GHz and a 6 ~15GHz MMIC FET amplifier, are presented to illustrate the applications.

I. Design Considerations

In recent years, GaAs microwave monolithic integrated circuits (MMIC) have attracted more and more attention, and may develop into a new generation of microwave component with mass production[1-3]. Therefore, a suitable computer-aided precision design procedure is very much needed.

Currently, the design procedures for microwave diodes and FET amplifiers are all based on scattering parameters of transistors, and the amplifiers are designed according to lossless matching network unit termination resistance (matching terminations)[4-14]. In most of these types of designs, the so-called $|S_{12}| = 0$ (unilateral design), the non-unilateral characteristics of the transistors are neglected[3-12], consequently, some errors are introduced in the design of transistors with large S_{12} values. For example, in the design of transistors with $|S_{12}| = 0.08 \sim 0.1$, assuming $|S_{12}| = 0$, then the transmission gain error is $0.6 \sim 2.5$dB, and the shape of the response curve is changed. (See Figure 1). Also, the components in the matching network suffer some losses. Neglecting these losses, especially when the frequencies are

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higher, will also introduce errors. For example, after taking into account the losses in the various matching networks in a design of a unilateral lossless network, the transmission gain will decrease by 1.5 ~2.5dB, and the shape of the response curve will also change somewhat. Therefore, in the unilateral design according to lossless matching network the difference between design gain and actual gain may reach 4.4dB. (See Figure 1)

At the MMIC termination, there is usually some parasitic capacitance and even parasitic inductance. Consequently, it is hard to achieve a perfect matching network for the MMIC amplifiers. In a minimax gain design according to the unit termination resistance (in accordance with lossy non-unilateral design), the two ends are both connected with 0.05pF parasitic capacitors and 50 Ω termination resistors, then the noise coefficients will increase by 0.15dB, and gains will change by 0.1 ~ 1.3dB. More importantly, the gain response is no longer a minimax response. (See Figure 2). Therefore, we have studied a more complete and more precise design method for MMIC FET amplifiers. This method takes into account the FET non-unilateral characteristics, matching network losses, and the effects of the complex termination mismatch on amplifier characteristics.

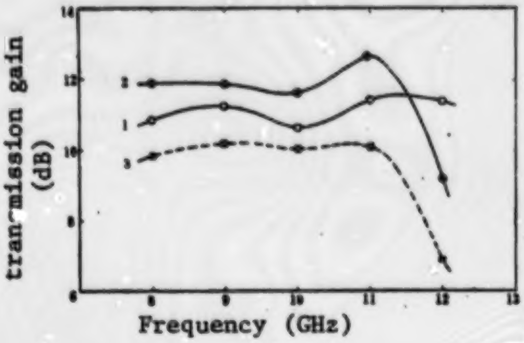


Fig. 1 FET Non-unilateral Characteristics and the Effect of Network Loss on the Amplifier Gain (TRW 0.5 μm FET)

Curve 1 unilateral design ($|S_{12}| = 0$), lossless network

Curve 2 Same amplifier, effect of $|S_{12}| \neq 0$

Curve 3 Same amplifier, effects of $|S_{12}| \neq 0$ and network loss

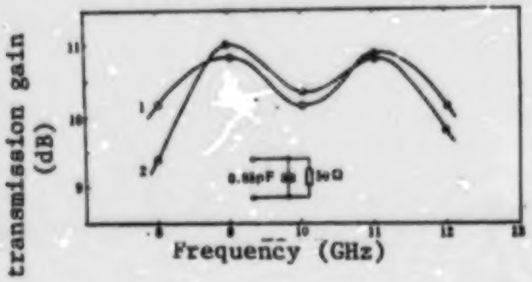


Fig. 2 Comparison of Matching Termination and Complex Termination Amplifier (non-unilateral simultaneous design, lossy network, TRW 0.5 μm FET)

Key:
1. Matching termination
2. Complex termination

II. Transmission Gains

When a solid state microwave amplifier has a lossy matching network, and the signal source and load admittance are complex (see Figure 3), then the general formula of transmission gain may be expressed as

$$G_T=\frac{(1-|\rho_g|^2)}{(1-|S_{in}|^2)}\ \frac{|S_{in}|^2}{(1-|S'_{in}|^2)}\ \frac{(1-|\rho_1|^2)}{(1-|S_{Tn}|^2)}|S_{Tn}|^2 \cdot\frac{(1-|\rho_2|^2)}{(1-|S'_{Tn}|^2)}\ \frac{|S_{on}|^2}{(1-|S_{on}|^2)}\ \frac{(1-|\rho_l|^2)}{(1-|S'_{on}|^2)} =G_{gi}\cdot G_{ii}\cdot G_{ti}\cdot G_{tt}\cdot G_{to}\cdot G_{oo}\cdot G_{ol} \qquad (1)$$

where G_{gi} and G_{ol} are respectively signal source and load matching gain; G_{ii} and G_{oo} are respectively input and output matching networks (NI and NO) loss attentuations; G_{ti} and G_{to} are respectively FET input and output matching gain; and G_{tt} is the fixed FET gain.

$$G_{gI}=\frac{1-|\rho_g|^2}{1-|S_{I11}|^2}=\frac{\text{Incidence power of } I_1 \text{ to NI}}{\text{available power at signal source}} \tag{2a}$$

$$G_{II}=\frac{|S_{I21}|^2}{1-|S'_{I22}|^2}=\frac{\text{Available power at } T_1}{\text{incidence power of } I_1 \text{ to NI}} \tag{2b}$$

$$G_{IT}=\frac{1-|\rho_1|^2}{1-|S_{T11}|^2}=\frac{\text{Incidence power from } T_1 \text{ to FET}}{\text{available power at } T_1} \tag{2c}$$

$$G_{TT}=|S_{T21}|^2=\frac{\text{FET transmitted power at } T_2}{\text{Incidence power from } T_1 \text{ to FET}} \tag{2d}$$

$$G_{TO}=\frac{1-|\rho_2|^2}{1-|S'_{T22}|^2}=\frac{\text{Power absorbed by NO at } T_2}{\text{FET transmitted power at } T_2} \tag{2e}$$

$$G_{OO}=\frac{|S_{O21}|^2}{1-|S_{O11}|^2}=\frac{\text{NO transmitted power at } O_2}{\text{Power absorbed by NO at } T_2} \tag{2f}$$

$$G_{Ol}=\frac{1-|\rho_l|^2}{1-|S'_{O22}|^2}=\frac{\text{Power absorbed by load}}{\text{Power absorbed by NO at } O_2} \tag{2g}$$

The normalized complex reflectivity coefficient is

$$\rho_k=(Y_i'^{*}-\dot{Y}_j)/(\dot{Y}_i'+\dot{Y}_j) \tag{3}$$

where k = g, 1,2,l; i = g, I2, T2, O2; j = I1, T1, O1, l; $\dot{Y}_i'$ is a unit normalized output admittance of a certain link when the entire fixed link is as shown in Figure 3. $\dot{Y}_i'$ is its conjugate complex number; $\dot{Y}_j'$ is the unit normalized input admittance of the next link when its output termination is the unit resistance.

$$\dot{Y}_i'=\frac{1-S_m'}{1+S_m'} \qquad \dot{Y}_j=\frac{1-S_N}{1+S_N}$$

where m = g, I22, O22 ($Y_g'=\dot{Y}_g$, $S_g'=S_g$); N=I11, T11, O11, ℓ.

All of S_{Iij}, S_{oij} and S_{Tij} (i,j=1,2) correspond to NI, NO and the FET scattering parameter, but S_{I22}, S_{T22} are the NI, FET and NO unit normalized output reflectivity coefficients of the last link shown on Figure 3.

$$S'_{l22}=S_{l22}+\frac{S_{l12}\cdot S_{l21}\cdot S'_{f22}}{1-S_{l11}\cdot S'_{f22}} \qquad (4)$$

where l = I, T, O; f = g, I, T ($S'_{g22} = S_g$).

Equation (1) is the most generalized formula for calculating the transmission gain of a solid state microwave amplifier, and it may be simplified to compute transmission gain under any special condition.

Under the conditions of a single signal source and load admittance, $Y_g = 1$, $Y_l = 1$, but $G_{gi} = 1$, and $G_{ol} = 1$, we can obtain

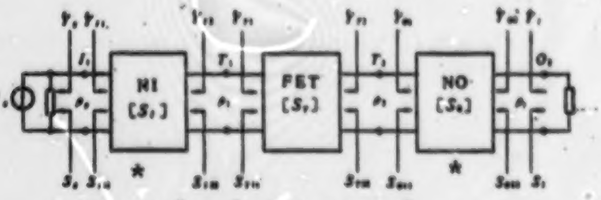
$$G_T=G_{ii}\cdot G_{it}\cdot G_{tt}\cdot G_{to}\cdot G_{oo} \qquad (5)$$

When the amplifier is designed with lossless matching network, $G_{ii} = 1$, $G_{oo} = 1$, then

$$G_T=G_{it}\cdot G_{tt}\cdot G_{to}=\frac{(1-|\rho_1|^2)}{(1-|S_{T11}|^2)}\cdot|S_{T21}|^2\cdot\frac{(1-|\rho_2|^2)}{(1-|S'_{T22}|^2)} \qquad (6)$$

This equation yields the same results as those obtained by Carlin and Komiak[13], and we call it the non-unilateral design formula. When $|S_{T12}| \ll 1$, i.e., neglegible, then the unilateral design formula may be obtained:

$$G_T=\frac{(1-|\rho_1|^2)}{(1-|S_{T11}|^2)}\cdot|S_{T21}|^2\cdot\frac{(1-|\rho_2|^2)}{(1-|S_{T22}|^2)} \qquad (7)$$



* = lossy network

Fig. 3 An FET Amplifier Possessing Lossy Matching Network and Complex Termination Admittance

III. Noise Measures

The FET amplifier noise coefficient is[17,18]

$$F_N=F_{min}+4R_F\frac{|S'_{I22}-S_F|^2}{|1+S_F|^2(1-|S'_{I22}|^2)} \qquad (8)$$

where F_{min} is the least FET noise coefficient, R_F is the unit normalized noise resistance of the FET, S_F is the optimal unit normalized noise reflectivity coefficient, $S_F = (1 - Y_F) / (1 + Y_F)$, and Y_F is the optimal unit normalized noise admittance of the FET.

For the first stage design of a low noise amplifier, the noise measure M_N can be used as a design criterion, it has also included the effects of noise coefficient and transmission gain G_T.

$$M_N = \frac{F_N - 1}{1 - 1/G_T} \tag{9}$$

For a two-stage amplifier, its total noise coefficient is

$$F_{Nt} = F_{N1} + \frac{F_{N2} - 1}{G_{T1}} \tag{10}$$

where F_{N1} and F_{N2} are respectively the noise coefficient of the first and second stage, and G_{T1} is the transmission gain of the first stage. When the first stage of the amplifier is designed according to the smallest noise measure, the total noise coefficient F_{Nt} is the smallest.

IV. Lossy Matching Network

In order to conserve the area occupied on the substrate, we use the lumped elements to build the matching network. In the microwave lumped elements, all of the losses will vary with the $\neq$ frequencies[1,2,20,21]. In the industance, including those in the band inductance and coiled inductance, or in the interweaving capacitance, the losses are skin losses, and they are proportional to the square foot of the frequency. In the metal-insulator-metal (MIM) inductance, there is a dielectric loss besides skin loss, and it is inversely proportional to the frequency.

Using a series equivalent circuit (see Figure 4), we have obtained the impedance of a lumped element:

$$\left.\begin{aligned} Z_L &= (\sigma_L \omega^{1/2} + j\omega) L \\ Z_C &= \left(\frac{\omega^{1/2}}{\sigma_C} - j\frac{1}{\omega}\right)\frac{1}{C} \\ Z_{Cd} &= \left[\left(\frac{\omega^{1/2}}{\sigma_C} + \frac{1}{\sigma_d \omega}\right) - j\frac{1}{\omega}\right]\frac{1}{C} \end{aligned}\right\} \tag{11}$$

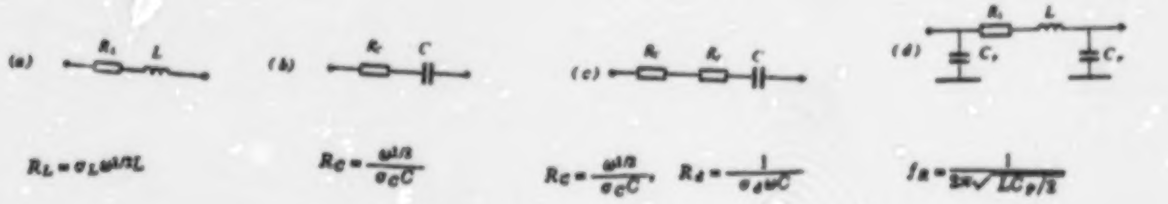
where Z_L, Z_C, Z_{Cd} are respectively the resistances to inductance, interweaving capacitance, and MIM capacitance. σ_L, σ_C and σ_d are constants, and they may be determined by the quality factor test value Q_T under certain normalized test frequency ω_T:

$$\sigma_L=\frac{\omega_T^{1/2}}{Q_{LT}},\quad \sigma_C=\omega_T^{1/2}\cdot Q_{CT},\quad \sigma_d=Q_{dT}$$

where Q_{LT} is the test value of inductance Q_T, Q_{CT} and Q_{dT} are respectively Q_T test values caused by skin loss and dielectric loss in the capacitance. The total Q_T value in the MIM capacitance can be determined as the following:

$$\frac{1}{Q_T}=\frac{1}{Q_{CT}}+\frac{1}{Q_{dT}} \qquad (12)$$

It should be noted, there may exist parallel ground capacitance C_p in the inductance (Figure 4d), and it may form a resonance with inductance L, and its frequency is[2]: $f_R = 1/2\pi \sqrt{LC_p/2}$. When the working frequency is near this resonant frequency in value, the test value Q_{LT} suffers a noticeable decrease. Therefore, in order to decrease the effect of parallel capacitance, one should ensure that $f_R \geqslant (2.5 \sim 3)f_u$ when designing a capacitance element, f_u is the upper limit of the working frequency.


(a)
R_1
L
(b)
R_c
C
(c)
R_c
R_d
C
(d)
R_1
L
C_p
C_p
$R_L=\sigma_L\omega^{1/2}L$
$R_C=\frac{\omega^{1/2}}{\sigma_C C}$
$R_C=\frac{\omega^{1/2}}{\sigma_C C}$, $R_d=\frac{1}{\sigma_d\omega C}$
$f_R=\frac{1}{2\pi\sqrt{LC_p/2}}$

(a) inductor (b) interweaving capacitor (c) MIM capacitor (d) inductor w. ground capacitance

Fig. 4 Equivalent Circuit of Microwave Lumped Element

V. Computer-aided Design Method

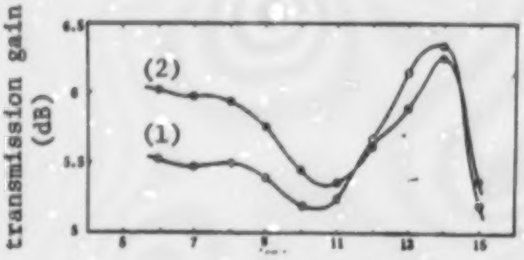
We have studied a computer-aided design method for a non-unilateral design of an MMIC FET amplifier with a lossy matching network and its two terminations having complex admittances.

The main program AMDI-OPTS is a multivariate constrained search method using a simplex domain algorithm[22,23]. After the designer has selected a suitable topology for the matching network and has given initial values for its elements, this program can calculate the transmission gains, noise coefficients, and noise measure for the amplifier. It can also use the minimax transmission gain[16] in the bandpass or the minimax noise measure as the objective function to search for the optimal value for the lossy element (inductance or capacitance) and to individually use the parametric conversion method and penalty method to satisfy the following constraints:

$$\left.\begin{array}{ll} a_i \leqslant x_i \leqslant b_i & (i=1,2,\cdots,n) \\ |S^j_k \cdot S^j_{TH}| \leqslant 1 & (j=1,2,\; k=I22,O11) \end{array}\right\} \qquad (13)$$

to ensure the element values can be realized within a given region (a_i, b_i are the lower and upper limits of the element values) and the stability of the FET input and output terminations.

Program AMDI-OPTS can also be used simultaneously to search for the optimal values of each element of the input and output matching network. Using this non-unilateral simultaneous design method, we can improve the results obtained from the individual designs of input and output networks. The computation results show that this kind of simultaneous method is suitable for designing the broad-band minimax gain (Figure 5) and minimax noise measure (Figure 6). This program can also be easily used to design the MMIC FET amplifiers with lossy or lossless matching networks and unit or complex termination admittance, taking into account various conditions of unilateral or non-unilateral properties.



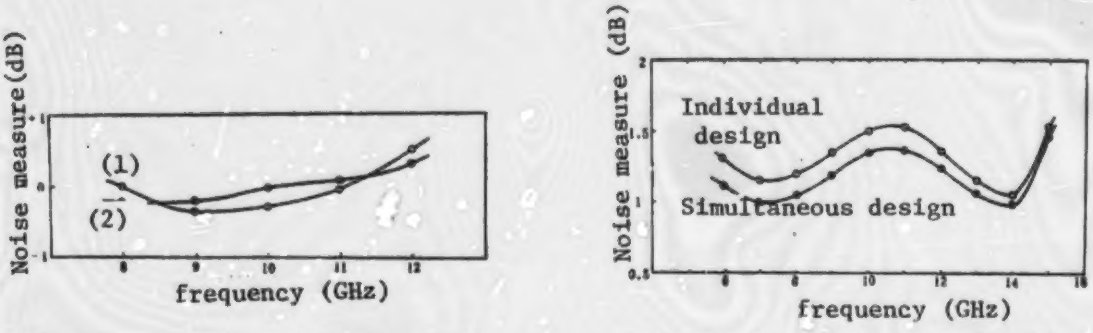
No 2 amplifier (NE388FET)

Fig. 5 Comparison of Non-unilateral Individual and Simultaneous Designs (lossy network, matching termination)

Key:

1. Individual design
2. Simultaneous design

In order to obtain the initial value of each element, we have used a computer-aided design program for any microwave solid state amplifier with lossless network and unilateral matching termination. We have frequently used a kind of simplified real frequency technique[25].



(a) No 1 amplifier (TRWO.5um FET)

(b) No 2 amplifier (NE388FET) minimax noise estimator design

Fig. 6 Comparison Non-unilateral Individual and Simultaneous Designs (lossy network, matching termination)

VI. Actual Design Examples

This paper introduces the results of two kinds of MMIC FET amplifiers, and each one is designed according to the minimum value of the gain in the bandpass being at maximum (minimax gain) or the maximum value of the noise measure in the bandpass being at minimum (minimum-maximum noise measure).

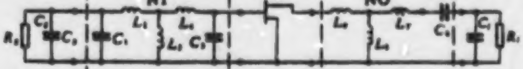


Fig. 7 No 1 Amplifier Wiring Diagram

Table 1. Initial Value of the Elements of No 1 Amplifier (Q = 30, Q = 50, 12GHz)

design format \ parameter	R_g(Ω)	C_g(pF)	C_1(pF)	L_1(nH)	L_2(nH)	L_3(nH)
minimax gain design	50	0.05	0.6096	0.1830	0.4337	0.4180
minimax noise measure design	50	0.05	0.3154	0.3172	0.4486	0.2469

design format \ parameter	C_2(pF)	R_l(Ω)	C_l(pF)	C_3(pF)	L_4(nH)	L_5(nH)	L_6(nH)
minimax gain design	0.1130	50	0.05	0.1158	1.5489	1.0487	1.5039
minimax noise measure design	0.0945	50	0.05	0.1255	2.7589	1.7405	1.1179

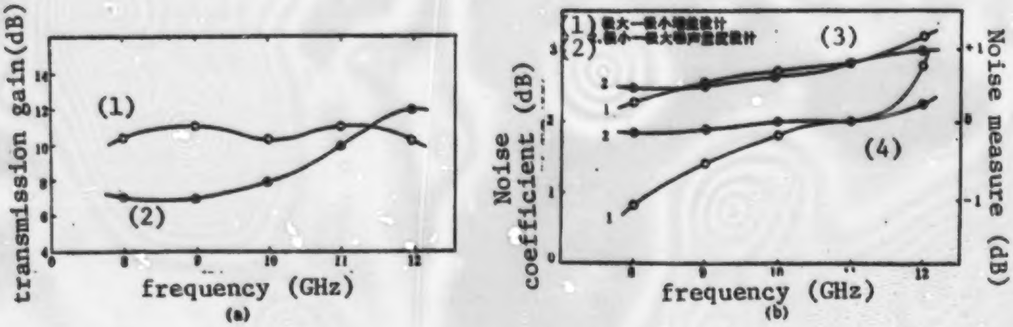


Fig. 8 Transmission gain, noise coefficients, and noise measures of No 1 amplifier

Key:

1. Maximum-minimum gain design
2. Minimax noise measure design
3. Noise coefficient
4. Noise measure

(1) The No 1 amplifier is an 8∼12GHz TRW 0.5 μm FET monolithic microwave integrated amplifier, its wiring diagram is shown in Figure 7, and the values of its values are shown in Table 1. According to minimax gain design, the bandpass gain is 10.56±0.38dB; and according to the minimum-maximum noise estimator design the obtained bandpass noise is 0.60±23dB (see Figure 8).

(2) The No 2 amplifier is a 6∼15GHz NE388 FET[26] monolithic microwave integrated amplifier, and its matching network wiring diagram is shown in Figure 9 and the values of its elements are shown in Table 2. According to the bandpass gain of 5.71±0.37dB obtained in the minimax gain design, and according to minimum-maximum noise estimator the obtained bandpass noise is 1.10±0.25dB. (See Figure 10).

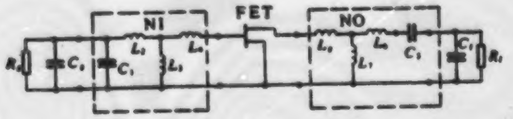


Fig. 9 No 2 Amplifier Wiring Diagram

Under the aforementioned situations, the amplifiers are all designed under the conditions of lossy lumped element matching network and signal source, and the load admittances are all complex numbers, and at 12GHz the quality factor test values are set at $Q_{LT} = 30$, $Q_{CT} = 50$. The complex admittances of the two terminations are both associated with the 0.05pF parasitic capacitance and 50Ω termination resistance. The inherent slanting decrease property of gain in the FET device has been considered in the design.

Table 2. The Values of No 2 Amplifier Elements (Q = 30, A = 50, 12GHz)

parameter / design format	R_g(Ω)	C_g(pF)	C_1(pF)	L_2(nH)	L_3(nH)	L_4(nH)
minimax gain design	50	0.05	0.1214	0.5856	2.7168	0.0453
minimax noise measure design	50	0.05	0.1404	0.6292	2.6374	0.0407
parameter / design format	**R_l(Ω)**	**C_l(pF)**	**C_5(pF)**	**L_6(nH)**	**L_7(nH)**	**L_8(nH)**
minimax gain design	50	0.05	0.1404	0.6292	2.6374	0.0407
minimax noise measure design	50	0.05	0.6400	0.2750	1.3023	0.3110

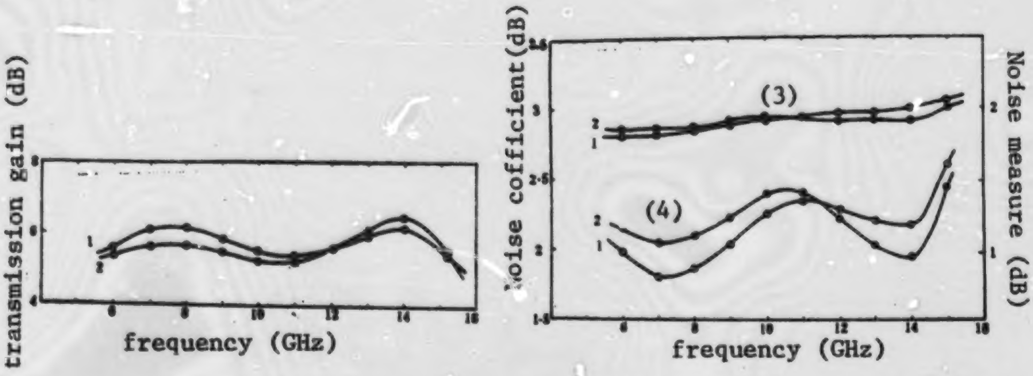


Fig. 10 Transmission Gain, Noise Coefficients, and Noise Measure of No 2 Amplifier

Key:

1. Maximum-minimum gain design
2. Minimum-maximum noise measure design
3. Noise coefficient
4. Noise measure

VII. Conclusions

The new computer-aided design procedure introduced in this paper has already been successfully used in designing lossy matching network and complex termination admittance noise and broad-band MMIC FET amplifiers. This method has taken into account the non-unilateral property, the loss associated with matching network frequency, and the complex numbers mismatch of the terminations of a FET. Therefore, it is more complete and precise than the other computer-aided design methods currently in use.

This kind of input and output matching network non-unilateral simultaneous design procedure has been illustrated by several actual design examples: it is suitable for use on design of minimum-maximum noise estimator and broadband minimax transmission gain measurement.

This technique can also be developed to design multi-stage MMIC FET amplifiers with lossy network and complex termination admittance, and for other types of microwave solid state amplifiers.

[APPENDIX] Derivation of the General Formula for Transmission Gain

Let a unit resistance be connected to the output termination of NI (port T_1, see Figure 3), i.e., $\dot{Y}_{T1} = 1$, $S_{T11} = 0$. The power absorbed by NI at port I_1 is:

$$P_{abs \cdot I1} = P_{av \cdot s}(1-|\rho_s|^2) \qquad \text{(A)}$$

where $P_{av.s}$ is the available power of the information source, $\rho_s = (Y_s^* - \hat{Y}_{I1})/(Y_s^* + \hat{Y}_{I1})$, $\hat{Y}_{I1} = (1-S_{I11})/(1+S_{I11})$. The power transmitted by NI at port I_1 is:

$$P_{tr \cdot T1} = P_{av \cdot s}(1-|\rho_s|^2)\frac{|S_{I21}|^2}{(1-|S_{I11}|^2)} \qquad \text{(B)}$$

Then, connect the next FET link, let a unit resistance be connected to the FET's output termination (port T_2) Treat all of the links before port I_1 as an equivalent power source, the available power at port T_1 is:

$$P_{av \cdot T1} = \frac{P_{tr \cdot T1}}{(1-|S'_{I22}|^2)} \qquad \text{(C)}$$

where S'_{I22} is the normalized unit output reflectivity coefficient of this equivalent power.

$$S'_{I22} = S_{I22} + \frac{S_{I21} \cdot S_{I12} \cdot S_s}{1 - S_{I11} \cdot S_s}$$

The power transmitted by FET at port T_2 is:

$$P_{tr \cdot T2} = P_{av \cdot T1}(1-|\rho_1|^2)\frac{|S_{T21}|^2}{(1-|S_{T11}|^2)} \qquad \text{(D)}$$

where P_1 is the complex normalized reflectivity coefficient.

$$\rho_1 = \frac{Y'^*_{I2} - \hat{Y}_{T1}}{\hat{Y}'_{I2} + \hat{Y}_{T1}}, \quad \hat{Y}'_{I2} = \frac{1 - S'_{I22}}{1 + S'_{I22}}, \quad \hat{Y}_{T1} = \frac{1 - S_{T11}}{1 + S_{T11}}$$

Substituting (B) and (C) into (D), we get

$$P_{tr \cdot T2} = P_{av \cdot s}\frac{(1-|\rho_s|^2)}{(1-|S_{I11}|^2)} \; \frac{|S_{I21}|^2}{(1-|S'_{I22}|^2)} \; \frac{(1-|\rho_1|^2)}{(1-|S_{T11}|^2)}|S_{T21}|^2 \qquad \text{(E)}$$

Using the same procedure on the following links, we can eventually obtain the ratio of the power of the amplifier transmission gain absorbed by the load and the signal source power, that is the general formula (1).

We thank Prof. Walter H. Ku of Cornell University for the useful discussion on some of the problems on this paper.

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APPLIED SCIENCES

ELECTROSTATIC LENS OF NEW TYPE FIELD EMISSION GUN

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 12, No 1, Jan 84, pp 119-121

[Article by Tu Yushan [1458 5124 0810] of the Institute of Electronics, Chinese Academy of Sciences: "Characteristics of the Electrostatic Lens of a New Type Field Emission Gun"; received October 1982, draft finalized April 1983.]

[Text] English Abstract: The construction and calculation results of a hyperboloidal field of unipotential electrostatic lens with low spherical aberration is presented, by which the performance of the electron optical system of the field emission gun can be easily improved.

In a field emission gun, the relationship between the optimum aperture angle α_{opt} and the maximum beam I_{max} and the spherical aberration coefficient of the lens C_{s2} are respectively

$$\alpha_{opt}=(d/C_{s2})^{1/3} \quad (1)$$

$$I_{max}=3^{1/4}\pi(dI/d\Omega)(V_2/V_1)^{1/4}(d^{2/3}/C_{s1}^{1/3}C_{s2}^{1/6}) \quad (2)$$

in which C_{s1} and C_{s2} are the spherical aberration coefficient of the gun's lens and the probe lens, respectively and $dI/d\Omega$ is the angular emission rate of the tip of the cathode. Figure 1 is the design of the three light paths used in the field emission gun. In the figure, (a) is the first stage electrostatic lens used mainly in when the image position and the beam energy are fixed and the emission is relative stable; (b) is the second stage focusing system, sometimes the second stage lens is a magnetic lens, in this construction, the system magnification can be reduced for higher resolution;

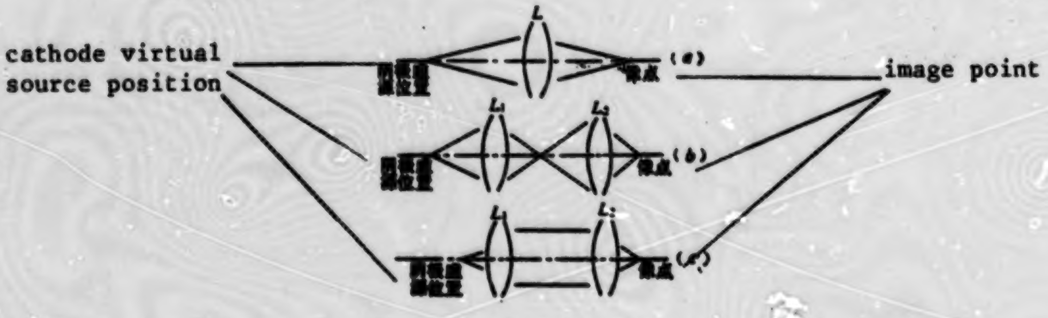
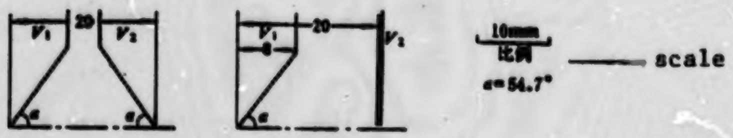

cathode virtual source position
L
(a)
image point
L1
L2
(b)
L1
L2
(c)

Figure 1. Design of three circuits of field emission gun

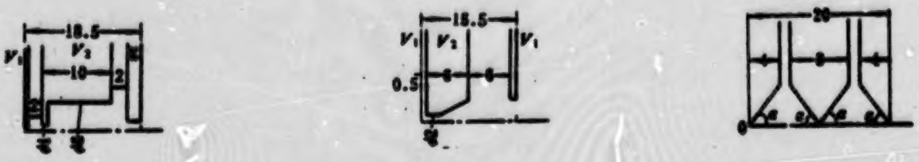
(c) is also a second stage focusing system, but the virtual source position and the lens focal position coincide, thus the influence of image aberration is minimal but the beam is very large (the geometric magnification of this system is the ratio of the focal length of the two lenses, and generally should be larger than the focal length of type (b)).

There are two types of electrostatic lenses now used in field emission guns: the dual potential lens and the unipotential lens. For the former, there are the simplified type in reference [1] and the hyperboloid lens of 109°28', and the latter includes the two asymmetrical structures in references [2] and [3]. Their typical construction is illustrated in Figure 2.


V_1
20
V_2
α
α
V_1
6
20
V_2
α
10mm
比例
α=54.7°
scale

(a) hyperboloid field dual potential

(b) Munro simplified type


18.5
V_1
V_2
10
2
18.5
V_1
V_2
V_1
0.5
6
6
20
6
6
6
0
α
α
α
α

(c) Septier asymmetrical structure

(d) Riddle asymmetrical structure

(e) hyperboloid unipotential

Figure 2. Electrostatic lens structures of various field emission guns, point 0 corresponds to the focusing position in Table 1

Dual potential lenses generally require high voltage, but the end potential is limited by the working voltage, the first anode voltage also directly affects the size of the beam, thus it primarily should be used in cases where the voltage is fixed and the image formation position is fixed. Commonly, the unipotential lens is used as a pre-acceleration lens and it can change the beam and the end voltage (energy) within a larger range. The author used a new type of hyperboloid field unipotential lens, and through computer analysis shows that this lens can obtain a smaller spherical aberration coefficient at a longer focal length. This hyperboloid field unipotential lens can serve as the first stage lens of a field emission gun. See Figure 2(e) for its structure and the dimensions of the electrodes.

The author feels that when the focal length of the Riddle lens in Figure 2 is very short, there is a very small spherical aberration coefficient, but this is not suited to use at high voltages; although there is a small spherical aberration coefficient with the longer focal length of the Septier lens, if the light path illustrated in Figure 1(a) is used, changes can occur in the main plane position, leading to changes in the beam tension angle and this makes the circle of confusion spots ($C_3a^3/2$) created by spherical aberration even larger. The two sides of the hyperboloid field unipotential lens are summetrical, thus a better image formation result is obtained. Figure 3 gives the curve of the relationship between the focal length of the various lenses and the spherical aberration coefficient, Table 1 is the computation results of the structure and characteristics of the lens of typical dimensions illustrated in Figure 2(e), and provides a basis for references when deploying electron optical systems.

Table 1. Characteristics of hyperboloid field unipotential lens illustrated in Figure 2(e)
(VOLTAGE $v_1 = 1$)

Voltage (V_2)	Physical Aspect						
	projection point		physical point		spherical aberration coefficient	color-difference coefficient	spherical aberration/ focal length
	focal position	focal length	focal position	focal length			
0	727.2	717.5	9.97	0.48	0.137	0.166	0.28
0.1	5.44	6.93	5.38	5.66	27.83	20.72	4.92
0.2	0.28	10.94	0.28	10.94	104.6	48.78	9.57
0.3	-6.71	17.43	-6.71	17.43	333.0	59.96	19.11
0.4	-17.78	28.22	-17.78	28.22	1231.8	85.83	43.66
0.5	-37.14	47.40	-37.14	47.40	5362.3	130.1	113.1
0.6	-52.65	62.84	-52.65	62.84	12017	165.5	192.6
0.7	-108.5	118.7	-108.5	118.7	71510	290.4	653.2
0.8	-252.7	262.8	-252.7	262.8	809150	602.7	507.9
1.5	-119.4	133.6	-199.4	113.6	84330	214.9	631.4
2	-37.43	41.83	-37.43	47.83	3402.1	64.65	71.1
3	-10.24	21.52	-10.24	21.52	278.8	21.37	12.96
4	-3.12	15.62	-3.12	15.62	119.4	43.93	7.64
5	0.50	13.65	0.30	13.69	93.48	11.74	6.83
6	3.16	13.24	3.10	13.31	136.7	23.6	8.93
7	5.71	13.86	5.12	16.34	166.6	42.8	10.20
8	8.76	15.59	6.63	16.16	163.9	57.04	10.14
9	13.21	19.09	7.76	15.63	149.9	65.3	9.59
10	21.46	26.64	8.66	14.84	136.3	69.4	9.19

1. Because this is a symmetrical structure, only the physical characteristics are listed.
2. The focus point position takes the left side of the left electrode in Figure 2(e) as the coordinate's point of origin.

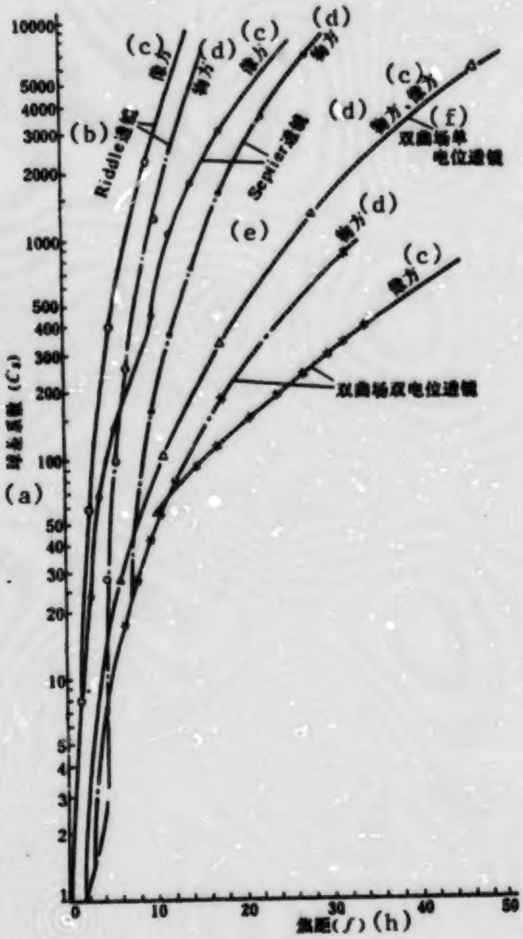


Figure 3. Curves of the relationship of focal length and spherical aberration of various lenses.

Key:

- a. spherical aberration coefficient
- b. Riddle lens
- c. image
- d. physical aspect
- e. Septier lens
- f. hyperploid field unipotential lens
- g. hyperploid field dual potential lens
- h. focal length

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APPLIED SCIENCES

TRENDS IN DEVELOPMENT OF ELECTRON OPTICS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 12, No 2, Mar 84 pp 90-96

[Article by Ximen Jiye [6007 7024 4764 2814], Beijing University, Department of Radio-electronics; received July 1983]

[Text] English Abstract: The main trends in the development of electron optics have been discussed. The following are noteworthy: rotationally symmetrical electron optics for the weak narrow electron beam, electron optical matrix algebra and optimization design, non-rotationally symmetrical multipole systems, the progress of scanning electron beam systems--a combined focusing-deflection system, electron optics for the wide electron beam, electron and ion optical systems with a curvilinear axis, wave electron optics. The future development and applications of electron optics have also been outlined.

Electron optics is a scientific field that studies the laws of electrons in focusing, image formation, and deflection in electromagnetic fields. Using classical dynamics, classical electrodynamics, and optics as the theoretical foundation and relying on the similarities between the movement of electrons and ions in electromagnetic fields and the propagation rays in optical media, adopting optics-like methods and concepts (such as variation principle, aberration function, refractivity, rays, lenses and aberration) people have established a complete theoretical system of electron optics to study and explain these laws [1,2].

The origins of electron optics theory can be traced back to the principle of the shortest optical path in the 17th century, Maupertuis-Eyler's principle of least action in the 18th century, and Hamilton's variation principle and Maxwell's electromagnetic theory in the 19th century. However, the real beginning of electron optics developed around the problem of rotationally symmetrical weak narrow beam electron optics. For example, H. Busch's treatise on magnetic focusing in 1926 and the theoretical articles of W. Glaser and O. Scherzer on rotationally symmetric electron optics in 1932-1937 laid the theoretical foundation for electron optics. In the past 50 years, with the development of science and technology and production practice, electron optics penetrated many areas of science and technology more and more each day. For example, the fields of ratio electronics, electron microscopy, mass-spectroscopy, surface physics, materials science, high energy physics, and plasma physics all involve problems of production, control and use of electron particle beams and all should use the achievements of this field of science. In terms of research and development and improving electron optics products (including components, instruments and devices) present electron optics theory is playing an extremely important role and the development of new components, instruments and devices is also opening up new areas and promoting their development for electron optics.

In looking at the prospects in this area on the basis of the flourishing development of electron optics, this paper stresses the introduction of some trends in the development of electron optics which are worthy of attention. For the principles of the electron and ion optics touched on in this paper please see reference [2].

Rotationally Symmetric Weak Narrow Beam Electron Optics

Rotationally symmetric weak narrow beam electron optics, which is the foundation of electron optics, is very highly developed and has a complete form. It is widely used in electron beam components (such as display tubes and oscilloscopes), electron optics instruments (such as transmissive electron microscopes and electron probes) and in electron optical equipment (such as electron beam exposer and electron beam processor).

An electron optics image formation system is made up of a certain number of rotationally symmetric electron lenses which can focus the electron rays to form an image. At present, the point resolution of high performance transmission electron microscopes is 2-3 A, with crystal lattice line resolution of about 1 A, they can observe the image of heavy metal elements and large molecules, and can directly scan and photograph the matrix and structure of crystals[3]; the resolution of scanning electron microscopes is 30-50 A, they can directly observe the surface image of samples and, when equipped with spectrograph, can carry out constituent analysis [3]. These achievements are outstanding applications of electron optics theory.

Electromagnetic deflection systems are made up of a magnetic field and an electrical field perpendicular to the electron beam's direction of motion and change the direction of the electron beam to produce deflection [4]. For example, the electrostatic or magnetic deflection system adopted in an electron beam component causes the electron beam to scan in order to record or display the image created; the magnetic deflection system used in an electron optical instrument or device makes the electron beam scan and deflect. The modern trinitron uses a perfected zihui juci [5261 2585 5112 4318] deflection coil to optimize the distribution of the deflected magnetic field (deflection angle 100°). This remarkable achievement drew on research on magnetic deflection system electron optics aberration [5,6]. Recently, reference [7] had done further work on third level aberration of magnetic deflection and electrical deflection.

Beginning in the sixties, and especially since the early eighties, computer-aided design has also been broadly applied to research and design in electron optics, successfully resolving the following problems [2,8].

(1) Computing electron fields and magnetic fields, including rotationally symmetric fields, deflection fields and multipole fields.

(2) Computing paths of motion of charged particles in electron and magnetic fields; solving equations of motion or equations of path taking space charged conditions into consideration or not (using processing methods of the single electron model or statistical model).

(3) Computing Gauss optical parameters in electron optics systems, including physical and image position of the image forming lens, magnification, focal point and focal length, and sensitivity of the deflector.

(4) Computing aberration, including geometric image and chromatic aberration of image forming systems and multipole systems, image aberration of deflection systems, and image aberration caused by other perturbation.

(5) Computing other optical performance norms, such as carrier function, resolution, imaging contrast and diffraction contrast, and phase, amplitude, and intensity.

Computer aided design makes classical electron optics theory and the development of components, instruments, and devices much easier and has vigorously promoted the development of weak narrow beam electron optics.

Electron Optical Matrix Algebra and Optimization Design

Multiple lens systems made up of a series of lenses or a multi-level deflection system made up of a series of deflectors in electron optics components, instruments, and devices can be viewed as an electron optics system. For example, three and four level image formation systems of transmission microscopes, the two and three level probe systems in scanning electron microscopes, and the dual deflection systems in electron beam exploders.

When designing multi-lens systems, an important problem is the need to determine accurately the system's Gaussian optical transformation properties and the image aberration transmission properties, and the properties of each lens and how its image aberration affects the ultimate image. In recent years, an entire matrix algebra method [2] has been developed in electron optics, that is defined as a series of matrices including the first level and third level path parameters, and their transformation between the initial plane and the final plane can be described by a transformation matrix. This transformation matrix comprehensively embodies the first level (Gauss) optical properties and third level image aberration properties of the lens. We have proven [9] that when an initial level image aberration exists in a rotationally symmetrical electron optics system, the determinant number of the transformation matrix is 1; when going through successive electron optics systems, the transformation matrix multiplies, thus the determinant number of the overall transformation matrix is also 1. This conclusion is the application of Liouville's theorem, and it contributed to the development of the matrix algebra theory of electron optics systems when there is initial level image aberration. We also studied superposition of image aberration in multi-level electro-magnetic deflection systems; the form of the formula obtained is simple and convenient for carrying out computer-aided and optimization design [10].

In recent years, great advances have been made in using computers for optimization design of electron optics systems. The basic topics in optimization design methods are: finding the optimal lens field distribution or structural parameters under conditions of restrictions on the parameters of lenses (such as geometrical shape and position, electron parameters or optical parameters) so that the total image aberration is minimal or does not go beyond a stipulated range and a perfected image is obtained. Thus the variational method [11], dynamic planning method [12], simplex method and complex method [13] can be adopted. Optimized design can carry out contrasts of a large number of plans according to a definite evaluation standard and rapidly select from among them the optimum scheme which conforms to certain demands. This accelerates the design and testing process of electron optics systems.

Non-rotationally Symmetric Multipole Systems

Historically, research on rotationally symmetric electron optic systems has been highly regarded. Later on, people strove to find better, more convenient and more effective electro-magnetic fields for electron beam focusing and image formation, so the non-rotationally symmetrical electro-magnetic multipole system came into being.

Electro-magnetic multipole systems are systems made up of several electric (magnetic) poles having a definite electric (magnetic) potential symmetrically placed in the direction of the bearing angle. The non-rotationally symmetrical fields produced by these multipole systems are multipole fields. Based on the above described symmetrical nature, the electric (magnetic) potential of multipole fields should be a periodic function of the space bearing angle direction. Thus, the problem of finding the spatial three-dimensional multipole field distribution becomes a problem of finding a series of two dimensional harmonic electric (magnetic) potentials. This Fourier derived method can find multipole fields precisely [14].

From this it can be seen that there are different focusing and defocusing in the meridian plane of different bearing angles in multipole fields. For example, four-pole lenses are focused in one meridian plane but in another meridian plane perpendicular to this one are defocused. Clearly, multipole systems are developments of rotationally symmetrical systems, have more varied natures, and can be broadly applied [15]. For example, four-pole, six-pole and eight-pole lenses in electron beam devices and electron microscopes are used as image aberration correctors (correcting axial astigmatism, central chromatic aberration, and spherical aberration); in mass spectrometers they are used as focus deflection components; and in accelerators they are used as beam transmission components.

As concerns the problem of eliminating spherical aberration in multipole lenses, in 1936, Scherzer [16] proved that in electron optical lens systems which do not have space charged, static and rotationally symmetrical image formation, spherical aberration cannot be eliminated. In 1947 he also proposed using an eight-pole lens system as a spherical aberration corrector [17], but this has not yet been very well realized due to the complexity of the structure and the difficulty of adjustment. In recent years, references [18] and [19] have proposed using magnetic six-pole lenses as spherical aberration correctors. The structure used by this method is simpler, adjustment is easy, and it has caught the attention of some people. Reference [20] discusses the optical properties of a complex system composed of a definite magnetic six-pole lenses distributed along the axis and graphic lens field distribution overlapping, and its second, third, fourth, and fifth level image aberration, but what is produced is only the image aberration (spherical aberration) in the Gaussian image plane and no image aberration outside the axis is produced. In reference [21] we further produce axial and extra-axial second, third and fourth level image aberration of a complex system formed by the overlap of any magnetic picture lens and the field distribution of a magnetic six-pole lens. These documents [16-18] all prove that the magnetic six-pole lens can correct the spherical aberration of picture lenses. If they are further realized in devices there can be very big breakthroughs.

New Developments in Scanning Beam Electron Optics: Focusing-Deflection Systems

Two different electron optics systems are used in ordinary electron optics devices. One type is the traditional and familiar fixed beam electron optics system (such as the image formation system of the transmission electron microscope). Its overall picture is produced at one time, thus frequently static methods are used to correct image aberration. The discussions in the above sections were referring to fixed beam electron optics systems. The other type is the relatively recently developed scanning electron optical system (such as the probe system of the scanning electron microscope and the picture production system of the electron beam exploder). Their electronic pictures are created by scanning points in succession in a series of instants, and thus dynamic methods can be used for correcting image aberration. This section will discuss the scanning beam electron optical systems. In this system, the electromagnetic lens is used to focus the electron beam and the electo-magnetic deflector is used to make the electron beam deflect the scan.

The focal field and the deflection field of the scanning electron optical systems of the scanning electron microscope and the electron probe are separated in space and do not overlap. Thus, the theory discussed in the proceding sections can be used for processing. The electron beam scan range in these devices is small (about several square microns) and thus the deflection image aberration is also small.

The scanning electron optical systems in electron beam exploders have their differences. This is because the manufacturing process of large scale integrated circuits demands that the electron beam exploders have large scanning ranges (several square millimeters), high resolution (submicron line width) and low image aberration. A unique scanning electron optical system has already been studied and designed, i.e., it will overlap in space the electro-magnetic lens field and the electro-magnetic deflection field to form a compound focus-deflection system. In this system, the magnetic deflection diagram is placed in the magnetic lens field, thus it can make some magnetic deflection image aberration supplement appropriately the extra-axial image aberration of the magnetic lens. The overall image aberration of this compound focusing-deflection system can be sharply reduced.

Since the seventies there have been great advances in research on compound focusing-deflection system electron optics theory [22-25]. We have derived the relative first level chromatic aberration and relative third level geometric image aberration of ordinary compound electro-magnetic focusing-deflection system and found clear equations for image aberration coefficients to facilitate electron optical design and numerical calculation by computer; we also discussed the problem of image overlap in multipole electro-magnetic compound deflection systems. Recently, reference [26] computed the field distribution and electron optical image aberration of compound focusing-deflection systems, discussed the problems of their optimized design and formulated corresponding general purpose procedures.

Recently, people have increasingly paid attention to correcting the image aberration of scanning electron optical systems. As discussed above, scanning electron optical systems can use dynamic methods to correct image aberration. Reference [27] says that in principal, third level image aberration of scanning electron optical systems can be eliminated. References [24] and [28] discuss the feasibility of adopting animated lens corrected image aberration in compound focusing-deflection systems. We discussed [29] the feasibility of using different electro-magnetic multipole fields as compound focusing-deflection systems dynamic image aberration correctors (such as using picture correction lenses, deflection correction fields and fourth level and sixth level correction fields), derived the corresponding image aberration equations, and proved that this dynamic image correction system can, under certain conditions, eliminate most of the third level deflection image aberration of compound systems.

Broad Beam Electron Optics Systems

In ordinary narrow beam electron optical devices (such as electron microscopes) and components (such as display tubes and oscilloscope tubes), the electron beam satisfies paraxial conditions, i.e., the distances from the axis are very small, and also very small relative to the gradient of the axis. Satisfying these conditions, approximate narrow-beam ideal Gaussian optical imaging properties can be derived and the tertiary geometric image aberration and primary chromatic aberration described using the paraxial path parameters.

In another large class of electron beam devices (such as image converter tubes and image intensifiers) the cathode emits electrons at a very small initial velocity; the cathode is immersed in the electrical field (and magnetic field) and is itself the surface of the object it is imaging. Thus, the electron beam does not satisfy the conditions of very small axial gradient (actually, the gradient of the electron beam intersecting the surface of the cathode tends to infinity), but it satisfies the conditions of being near the axis, i.e., the distance from the axis is very small and the horizontal velocity is very small. This type of electron beam is called the broad electron beam. Satisfying the adaxial condition, the approximate broad-beam ideal Gaussian optical imaging expression can be derived and the tertiary geometric image aberration and primary chromatic aberration described using the adaxial path parameters [30].

The author's strict theory of electromagnetic compound focusing cathode lens tertiary image aberration first established in 1957 [30] laid the foundation for broad-beam electron optics development. Recently there have been other developments [31] deriving image aberration of electromagnetic compound focusing lenses in any imaging plane.

For a long time in traditional electron optics documents, people have felt that narrow beam electron optical systems and broad-beam electron optical systems are two different kinds of systems, therefore they have used different methods to compute image aberrations. Recently, in reference [32], the author and other collaborators, proceeding from the variation principle, have studied image aberration theory of electromagnetic compound focusing cathode lenses, and obtained general equations for image aberration coefficients in any plane. They can be expressed using the image aberration coefficient linear composition derived by Glaser [1]. This demonstrates that image aberration of broad-beam and narrow-beam electron optical systems can be processed using uniform variation methods and thus establishes a connection between the two.

With developments in picture intensity technology, television technology, and electron photography technology, there have also been developments in broad-beam electron optics focusing theory [33], i.e., theoretical analysis of electromagnetic concentric focusing systems and electron optics research on inclined electromagnetic focusing systems.

Curvilinear Axis Electron and Ion Optical Systems

Traditional electron optics systems are straightline axis electron optics systems, and in them the primary paths of paraxial or adaxial electron beams are rotationally symmetrical straightline axes. However, there is a large class of widely used devices with charged particle (including electrons and ions) spectrographs which generally use curvilinear electron and ion optical systems--different types of electron field and magnetic field analyzers. Such electron field analyzers as cylindrical capacitors, spherical capacitors, and ring capacitors or uniform magnetic field and non-uniform magnetic field analyzers are used in charged particle spectrographs. The electron and magnetic fields of these analyzers are rotationally symmetrical fields. If the symmetrical surface of the mirror image perpendicular to the rotationally symmetrical axis is taken as the reference plane, the charged particle beams in this plane have cylindrical paths. Thus it can be seen that this is a curvilinear electron and ion optical system and is quite different from the straightline axis electron optics systems discussed above.

The most important characteristic of the curvilinear electron and ion optics systems is that they have special mass dispersion and energy dispersion properites. In fact, when charged particles of certain charge, certain mass, and certain energy (or momentum) is moving in an electron or magnetic field, they move along a cylindrical path with a definite radius in the mirror image plane. When charged particles have mass dispersion, energy dispersion, or momentum dispersion, the primary path will shift laterally (radially) and this is called chromatic aberration. Charged particle spectrographs can be manufactured using precisely this chromatic dispersion property: the analytical device which makes charged particles split according to mass is called a mass spectrograph; the analytical device that makes charged particles split according to energy and momentum is called an energy spectrograph. Next, the curvilinear electron and ion optics system on the one hand causes deflection in the charged particle beam (corresponding to the optical prism) and, on the other hand, also makes the charged particle beam focus (corresponding to the optical lens). Actually, this is a combination of prism and lens, generally called an ion lens. The commonly used ion lenses are fan-field ion lenses, i.e., the field distribution of the electron or magnetic field analyzer is limited to a certain fan field angle, and the intensity outside this fan field domain is zero. Apart from having the deflection and focusing functions described above, this type of fan field ion lens can also be used for describing optical properties in terms of such concepts as focal point and focal length. In primary approximation it can be proven that fan-shaped ion lenses have ideal focusing properties; if secondary and tertiary influences are considered, secondary and tertiary image aberrations will appear.

In references [2, 34, 35] we discussed universal electron field-magnetic field analyzers, i.e., ring-shaped electron fields and heterogeneous magnetic field orthogonal configuration fan-shaped overlapping field analyzers; expounded the secondary and tertiary ion optics theory of such fan-shaped overlapping fields and obtained matrix notation forms for secondary and tertiary ion paths and derived secondary and tertiary ion optics image aberration coefficients; discussed the transformation matrices of primary to secondary overlapping field ion lenses and proved that Liouville's theorem still held up to tertiary approximations. Recently we also derived secondary and tertiary transformation matrices under the action of fan-shaped overlapping field gradient exit and entrance [36]. These universal theories are important for developing fan-shaped ion optics theory and matrix algebra methods.

With the development of ion optics theory [37], high performance and multifunction mass spectrometers are constantly appearing. For example, the isotope mass spectrograph with a precision of 1ppm; the organic mass spectrograph with a resolution of 150,000, the solid micromass spectrograph which measures 10^{-10}, the ion probe spectro-micrograph analyzer which can analyze solid microregional (1 m^2) impurity distribution and depth (dozens of angstroms) impurity distribution of solids.

In recent years the performance of electron energy spectrographs has constantly improved and correspondingly, electron energy spectrography has also developed rapidly [38]. Thus, we should point out an important event, i.e., K. Siegbahn, a physicist and professor at Upsala University in Sweden won the Nobel Prize for physics in 1981 because of his outstanding contributions in many years to developing high resolution X-ray electron energy spectrographs and developments in X-ray electron energy spectrography. This fact suggests a bright future for this new science.

Wave Electron Optics

Although many properties of image formation systems can be explained using geometric optic concepts (such as electron rays, focal point, focal length and geometric image aberration) some phenomena related to electron waves (such as interference, diffraction, Fresnel fringe, resolution and transmission functions) must be explained with the help of wave electron optics.

The foundation for wave electron optics was laid in the fifties by Glaser *et al*. [1]. Wave electron optics placed the emphasis on studying the wave properties of electron beams propagated in macro-electromagnetic fields (such as electron microscope lens fields) and microelectromagnetic fields (such as internal potential electron fields in crystals) and other laws (such as electron beam interference, diffraction and image formation). In the last 20 or 30 years there have been great developments in wave electron optics and have been broadly applied in electron microscopy [39] and electron diffraction physics [40].

Viewed from the perspective of the concepts of physics, the imaging mechanism of the electron microscope can be explained in terms of Abbe's theory of image formation [41]. The first step, the sample corresponds to a diffraction grating; with coherent illumination, parallel incident waves produce diffraction waves due to the scattering action of the sample, and through the back focus surface of the lens they form a diffraction image. The second step, the diffraction images are viewed as secondary disturbance centers, and generate interference in accordance with Huygen's principle, thus the image formation is refocused on the image surface. Using the strict Fourier transformation method, the first step is to obtain a diffraction spectrum on the back focus surface after the physical surface waves have been through the Fourier transformation; the second step is the formation of the final image on the image plane from the diffraction spectrum, again through Fourier transformation; the diaphragm and the lens image aberration can be reduced by adjustment of the diffraction spectrum. Thus, proceeding from Schroedinger's equation of the electron wave function, Fourier transformation is used to find the wave function in rotationally symmetrical electromagnetic fields with paraxial approximation and tertiary image aberration, and the next step is to compute the transmission function. The above described theory is called wave (Fourier) electron optics.

In recent years, high resolution electron microscopy has developed very rapidly and matched with computer digital image processing technology, research on electron microscope image processing is all the rage. An event which should delight all of us workers in electron optics is that Dr. A. Klug, of the British Medical Research Council's Molecular Biology Laboratory won the Nobel Prize for Chemistry in 1982 for his outstanding contributions in developing crystal electron microscopy and his research on the crystal structure of nucleic acid-protein complex [42]. It was Klug who developed an entire image processing method based on the Fourier transformation relationship of electron microscope image formation. This improved the chendu, clarity and resolution of electron microscope images, and thus opened new paths for using electron microscope in the study of large molecules and other solid crystal structures.

Conclusion

This section looks forward to the future development and application of electron optics. In the eighties, the resolution and sensitivity of electron and ion optics analytical devices will constantly improve and may play a greater role in exploring the micro-world (for example, direct observation of atoms). In large scale and very large scale integrated circuits, adopting sub-micron diameter electron beam ultra-narrow-beam processing technology (by the end of this century we may achieve atomic level processing technology) will be helped by the development of ultra-high speed, ultra-large capacity computers. New developments in electron beam devices will certainly give rise to innovations in television, telecommunications, and photoelectric technology so that radio electronics will have a new look. New achievements in electron and ion optics and the design and manufacture of newer high energy accelerators and synchronous emanators will provide more powerful techniques for studying basic particles and mass structures. It can be estimated that electron and ion optics will play a larger role in science and technology and from this will draw driving forces and bring about greater developments in theory.

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APPLIED SCIENCES

CALCULATING INTERCONTINENTAL VEHICLE RANGE, ACCURACY

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[Article by Cai Yongfang*[5591 3057 5364] of Fuzhou Teachers' Vocational School]

[Text] This article provides a simplified means to calculate the range and accuracy of intercontinental rockets as well as working out the range and accuracy of China's first intercontinental rocket.

To facilitate computation below, the earth is treated as a perfect sphere of radius R = 6,371 km.

I. The Range and Launch Direction Angle of Intercontinental Rockets

1. Range of intercontinental rockets. Set the geographical coordinates of the launch point A and the descent point B to the (φ_1, θ_1) 及 (φ_2, θ_2), where $-90^\circ \leqslant \varphi_i \leqslant 90^\circ$, $-180^\circ \leqslant \theta_i \leqslant 180^\circ$, $i = 1, 2$. For points A, B construct meridian circles $\overset{\frown}{NAP}$ and $\overset{\frown}{NBQ}$ respectively and the great circle $\overset{\frown}{AB}$ where N is the north pole and great circle $\overset{\frown}{PQ}$ is the equator.

There is no harm in treating the earth as a unit sphere. In the spherical triangle $\triangle ANB$, $\overset{\frown}{NA} = \frac{\pi}{2} - \varphi_1$, $\overset{\frown}{NB} = \frac{\pi}{2} - \varphi_2$, $\overset{\frown}{AB} = \angle AOB = \phi$ (where 0 is the center of the earth), the angle $ANB = \angle POQ = \theta_2 - \theta_1$. From the cosine law for sides

$$\begin{aligned}\cos\phi &= \cos\left(\frac{\pi}{2} - \varphi_1\right)\cos\left(\frac{\pi}{2} - \varphi_2\right) \\ &\quad + \sin\left(\frac{\pi}{2} - \varphi_1\right) \\ &\quad \cdot \sin\left(\frac{\pi}{2} - \varphi_2\right)\cos(\theta_2 - \theta_1) \\ &= \sin\varphi_1 \sin\varphi_2 + \cos\varphi_1 \cos\varphi_2 \cos(\theta_2 - \theta_1),\end{aligned}$$

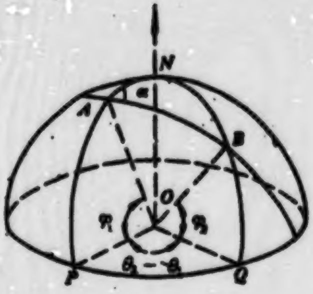

Figure 1.

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thus $$\phi = \cos^{-1}[\sin\varphi_1 \sin\varphi_2 + \cos\varphi_1 \cos\varphi_2 \cos(\theta_2 - \theta_1)], \qquad (1)$$

and the range of an intercontinental rocket is the shortest distance between the two points A, B

$$L = R \cdot \phi. \qquad (2)$$

According to inferences from [4], [5] it is known that China's first transport rocket was launched from Jiuquan in the northwest. From geographical calculation the coordinates of Jiuquan are approximately 39°42'N 98°28'E and the predetermined descent point is 7°S 171°33'E in the Pacific Ocean so with $\varphi_1 = 39°42'$, $\theta_1 = 98°28'$; $\varphi_2 = -7°$, $\theta_2 = 171°33'$ inserted in (1) we get

$$\phi = 81°42' = 1.4259 \text{ (radians)}$$

From (2) we get the rocket range

$$L = 6371 \times 1.4259 = 9084.4 \text{ (km)}$$

2. Launch direction angle. In the spherical triangle $\triangle ANB$, the angle NAB is the included angle between the northern direction of the meridian passing through the launch point and the projection of the flight path on the earth. Making $\angle NAB = \alpha$, from the law of sines

$$\frac{\sin\left(\frac{\pi}{2} - \varphi_2\right)}{\sin\alpha} = \frac{\sin\phi}{\sin(\theta_2 - \theta_1)}$$

we get the launch direction angle

$$\alpha = \sin^{-1}\left[\frac{\sin(\theta_2 - \theta_1)\cos\varphi_2}{\sin\phi}\right]. \qquad (3)$$

Substituting the values for $\theta_1, \theta_2, \varphi_2, \phi$ into (3) the launch direction angle of the rocket at Jiuquan is

$$\alpha = 73°38'30''.$$

II. Flight Path Deviation

Suppose the rocket descends within the circular region σ with the point B as center and radius r. Because r is usually greater than 10km, in these cases σ is actually a spherical segment.

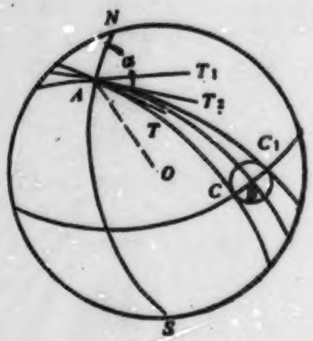

Figure 2

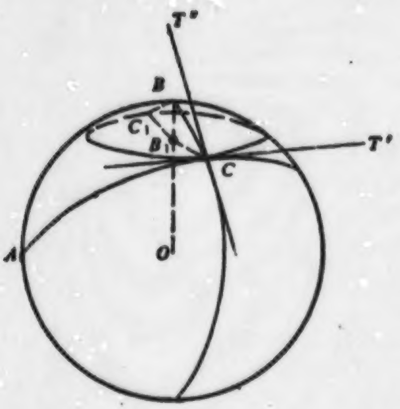

Figure 3

Make the two great circles through the launch point A tangent to σ (the base circle of the spherical segment) at the points C and C_1. The necessary but not sufficient condition to make the descent point within σ is that the flight path must lay within the solid angle C-DA-C_1 formed by the two half planes OAC and OAC_1. This angle is the maximum deviation angle that can be tolerated in the aiming direction at launch time. Below, it will be shown that this angle is twice the launch direction angle deviation $\Delta\alpha$ (i.e., spherical angle CAB).

To get $\Delta\alpha$, make great circles through B, C obtaining the spherical triangle $\triangle$ACB. Suppose the earth turned about the center O to make B occupy the place originally occupied by the north pole and to place A as in the outline of the earth in Figure 3. Now the circular region σ is the spherical segment BCC_1 and the arc $\overset{\frown}{CC_1}$ about the small circle B_1 is equivalent to a parallel [of latitude] and the great circle arc $\overset{\frown}{BC}$ is equivalent to a meridian [of longitude]. Make CT' and CT" be the tangents at C to $\overset{\frown}{CC_1}$ and $\overset{\frown}{BC}$ respectively. Because parallels and meridians are mutually perpendicular, CT'⊥CT", and since $\overset{\frown}{CC_1}$ and $\overset{\frown}{AC}$ intersect at the point C, CT' is also a tangent to $\overset{\frown}{AC}$ and as a result

$$\overset{\frown}{AC} \perp \overset{\frown}{BC} \text{ and the spherical angle ACB} = 90°.$$

In the spherical right triangle $\triangle$ACB, apply the law of sines

$$\sin A = \frac{\sin \overset{\frown}{BC}}{\sin \overset{\frown}{AB}} \qquad (\text{angle } A = \Delta\alpha\ ),$$

thereupon

$$\Delta\alpha = \sin^{-1}\left(\frac{\sin \overset{\frown}{BC}}{\sin \overset{\frown}{AB}}\right), \tag{4}$$

in which the great circle arcs $\overset{\frown}{AB}$, $\overset{\frown}{BC}$ are equal to the respective measure of the angles made from the center of the earth and can be found from the range and radius of the descent area respectively.

Similar to the above, make the great circle arc $\widehat{BC_1}$ (the great circle arcs $\widehat{BC_1}$ and $\widehat{BC}$ are not coplaner) and similarly $\widehat{AC_1}$ $\widehat{BC_1}$. Moreover from the formulae for spherical right triangles it is not difficult to show that

$$\angle CAB = \angle C_1AB, \text{ that is } \angle TAT_2 = \angle T_2AT_1,$$

in which AT, AT_1, AT_2 are the tangents through point A (Figure 2) to the great circle arcs $\widehat{AC}$, $\widehat{AC_1}$, and $\widehat{AB}$ respectively.

Moreover since

$$AT \perp OA, \ AT_1 \perp OA,$$

then:

The plane angle $\angle TAT_1$ of the solid angle C-OA-C is equal to 2 $\angle TAT_2$; that is the maximum deviation angle is equal to twice the launch deviation angle $\Delta\alpha$.

A great many factors influence the deviation in the rocket's descent point apart from errors in the launch direction angle, there is instrument error caused by the guidance system instrumentation, systematic error caused by simplifications in the guidance equations, error caused by propulsion residual when the engines shut down in the powered phase of the trajectory, and reentry errors which arise from changes in atmospheric elements during reentry of the projectile nose. Only after complex calculation and precise exterior trajectory measurement can the errors be evaluated. For more advanced discussion of these aspects see [1].

According to the "Public Notes" the radius of the descent area of our transport rocket was r = 70 nautical miles = 129.64km. But aside from considerations of safety caused by the rocket's probable descent error there is also consideration of the needs of exterior trajectory measurement work done in the descent area. For these reasons here we use 1/n (n = 1,2,...) of the radius of the descent area to estimate the accuracy.

In formula (4) $\widehat{AB} = 81°42'$, $\widehat{BC} = 1/n(r/R) = 1/n(129.64/6{,}371) = 1°10'/n$ thus the deviation in rocket launch direction angle came out to be

$$\Delta\alpha_n = \sin^{-1}\left(1.01059 \sin\frac{1°10'}{n}\right) \approx \frac{1°10'}{n}. \qquad (5)$$

When n = 1,2,3,... the launch direction angle deviation of corresponding radii of descent r, r/2, r/3, ... are

$$\Delta\alpha_1 = 1°11', \ \Delta\alpha_2 = 0°35', \ \Delta\alpha_3 = 0°23', \cdots.$$

This shows that when rockets follow a flight path within dihedral angles with separate plane angles of 2°22', 1°10', 0°46' and have a range around 9,080km they must descent in a circular area with B(-7°, 171°33') as center and have radii of 70, 35, 23.3 nautical miles respectively.

According to [6] or AFP Canberra dispatch ("Reference Information" 1980,5,20), on the basis of actual observation, the Australian Ministry of Defense said that the Chinese rocket splashed down at 7°S latitude and 172° E longitude. If this is correct then from B(-7°, 171°33') and B_1(-7°, 172°) on the basis of equation (2) we can get the spherical distance between these two points which is the descent point deviation.

$$\overset{\frown}{BB_1} = 6,371 \times 0.00771 = 49.1(\text{km}).$$

Also from equation (4) the deviation in launch direction angle comes out to be

$$\Delta\alpha = \sin^{-1}\left(\frac{\sin \overset{\frown}{BB_1}}{\sin \overset{\frown}{AB}}\right) = 0°26'47''.$$

As mentioned previously, the factors influencing deviation at the descent point are many, so for the time being we take $\Delta\alpha = 0°26'47''$ as the "equivalent aiming angle deviation" of the rocket's trajectory.

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'FUZZY INFERENCE' SYSTEM TO DIAGNOSE AIRCRAFT HYDRAULIC FAULTS

Beijing SHUXUE DE SHIJIAN YU RENSHI [MATHEMATICS IN PRACTICE AND THEORY] in Chinese No 3, Jul 85 pp 14-18

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[Text] I. Introduction

Aircraft hydraulic systems, the drive systems which control attitude, extension and retraction of landing gear, and wing flaps, are composed of tens to over a hundred parts. These systems are complex and often give rise to puzzling faults. At present, reliance on visual signs and dependence on experience to judge the location of the causes of faults contribute to a greater incidence of 'flying blind,' waste of time and material, and forfeiture of combat readiness. The application of computers in fault diagnosis can increase precision and speed so as to conveniently array the prerequisites which create the fault. This is one effective way to improve the quality of aircraft maintenance.

The causes of system faults and the appearance of symptoms have a random or "Fuzzy" nature. In the process of diagnosis the language people use is also largely "vague." For example, "the pressure is low and the landing gear retracts slowly," "large clearance causes fierce indicator oscillation," etc. The diagnostic process actually is a kind of vague inference process. That is, relying on experience to detect various "relations" between causes and symptoms and to engage in inference. In this regard, currently a large quantity of experimental statistical material has already been amassed. Based on these statistics combined with fault mechanism analysis, this article takes natural language and transforms it into machine language and crystallize human experience to simulate a "Fuzzy inference" system.

The characteristic nature of the system is first to select from events a set of symptoms (input) and causes (output) of model fault events and store them in a computer. Then during diagnosis an input works in this system to diagnosis the causes (output).

Using an H-89D microcomputer to do retrospective diagnosis of 48 instances of faults in a certain model aircraft hydraulic system, 39 cases were diagnosed correctly the first time. Seven were diagnosed correctly after two or three times and in only four cases was there a discrepancy between diagnosis and reality. Since the input and output both were in current common language it is not necessary to add other test information. It can be conveniently excluded and this satisfies people. This is where the application of "Fuzzy mathematics" to complex aeronautic equipment maintenance via a computer to combine human and machine diagnosis methods performs an advantageous service.

II. Establishment of a "Fuzzy Inference" Diagnostic Model

Diagnosis from symptom to cause can be understood as the continuation of two mappings. One is a mapping from major symptoms to cause type and the other is a mapping from auxiliary symptom to cause location. This is the general skeleton of "Fuzzy inference." Setting up two classes of mapping f_I and f_{II},

$$f_{\text{I}}: S \to D, \qquad (1)$$

$$f_{\text{II}}: A \to K, \qquad (2)$$

in which $S = \{s_1, s_2, \cdots, s_g\}$ is the complete set of major symptoms and $s_m (m = 1, 2, \cdots, g)$ are the concrete symptoms of each, $D = \{d_1, d_2, \cdots, d_n\}$ is the complete set of classes of causes and $d_j (j = 1, 2, \cdots, n)$ are the concrete causes of each, A = $\{a_1, a_2, \cdots, a_r\}$ is the complete set of auxiliary symptoms are $a_u (u = 1, 2, \cdots, r)$ are the concrete auxiliary symptoms of each. K = $\{k_1, k_2, \cdots, k_l\}$ is the complete set of cause locations, and $k_v (v = 1, 2, \cdots, l)$ are the concrete cause locations of each.

If $W = \{S, A\} = \{w_1, w_2, \cdots, w_{g+r}\}$ is used to represent the complete set of symptoms, then this provides the input of a set of symptoms $W_0 \subseteq$ W, and, under the function of the two classes of mapping above, output of the corresponding cause classes $d_j \in D$ and cause locations $k_i \in K$.

(1) The partition of symptom groups

Before determining the special characteristic of one or two class mappings, the symptoms obtained from experimental statistics must be partitioned into major and auxiliary symptoms. The principles of partition are determined according to the quantity of information provided by the symptom in diagnosing cause classes.

Make $P(d_j | w_i) = \frac{N_{d_j}}{N_{w_i}}$ be the probability that with the symptom w_i the cause d_j will produce a fault. In the formula, N_{w_i} is the frequency of times the symptom w_i occurred and N_{d_j} is the frequency with which the fault, d_j occurred when the symptom w_i appeared. Moreover, $P_{(w_i)} = \{P_{(w_1)}, P_{(w_2)}, \cdots, P_{(w_{m+r})}\}$ is the probability distribution of symptom w, $P_{(w_i)} = \frac{N_{w_i}}{N_w}$, , in which N_w is the general frequency of appearance of all symptoms. N_{d_j}, N_{w_i}, N_w, above all can be gotten from experimental statistics. This way the entropy equation which corresponds to $P(D \mid w_i)$ is

$$H(D|w_i) = -\sum_{j=1}^{n} P(d_j|w_i)\log_2 P(d_j|w_i), \tag{3}$$

and the corresponding average entropy is

$$H(D|w) = \sum_{i=1}^{m+r} P(w_i)H(D|w_i). \tag{4}$$

Selecting a level β, make symptom w_i where $\frac{H(D|w_i)}{H(D|w)} \leqslant \beta$ is the required major symptom; that is distinguish cause class d_j as the required symptom with more information and the others with less information are auxiliary symptoms. With regard to related symptoms $w_i, w_g, H(D|w_i) = H(D|w_g)$ $(i \neq g)$, then w_i, w_g both are auxiliary symptoms.

For a certain model, mechanical analysis of faults can be divided into four types: major pressure supply (d_1), auxiliary pressure supply (d_2), the extension and retraction sections (d_3), and the jet hydraulic control section (d_4).

According to over 10 years of statistics (not complete) for this model we get up to 65 symptom groups. Using $\beta = 3.2$ the above method screens out 12 of them as major symptoms; the rest all being auxiliary symptoms. For example, "vibrations of pressure gauge," "servo system pressure insufficient," "retraction of landing gear slow," and "afterburner jet engages slowly" are major symptoms. Represented sequentially we have the set of major symptoms $S=(s_1, s_2, \ldots, s_{12})$.

2. Determination of the characteristics of the first mapping

Selecting one set of typical fault incidents from experience, each incident can be described using a Fuzzy conditional sentence. For example, a certain aircraft is taxing slowly and the major system pressure is below normal values and also has strong oscillations. Later it was determined that the pump had a faulty piston. In the example of this incident, "system pressure below normal" and "strong oscillations" are major symptoms which in symbols would be, respectively, $s_7, s_6 \in S$; moreover, "non-working piston" belongs to the major pressure supply (d_1) class of causes, so the sentence is expressed as

$$\text{IF } s_7^1、s_6^1 \text{ THEN } d_1.$$

Similarly, we can obtain the corresponding set of conditional statements

$$\text{IF } s_{m_i}^j \subseteq S \text{ THEN } d_j \ (j = 1, 2, 3, 4),$$

where the superscript "j" in $S^i_{m_i}$ corresponds to the set of causes d_j and the subscript "i" indicates the ith conditional statement and "m" is its identification number.

Considering that the function of the appearance of each concrete symptom in the determination of the class of causes is not the same, that is the level of subordination of s_m with respect to d_j is not the same, the function of its subordination is

$$\mu^{j}_{m_j} \triangleq \begin{cases} \mu_{m_j}, & s_m = s^{j}_{m_j}, \\ 0. \end{cases}$$

Obviously for a certain symptom $s_m \in S$, the greater is use in diagnosing cause type d_j, the greater is its corresponding degree of subordination. In the determination of the size of the degree of subordination many kinds of factors must be considered. First to be considered are experimental statistics, second, in order to supplement the limitations of statistics, we must consider factors of mechanical analysis, the obvious degree of the symptom as it appears, and the degree of difficulty to obtain said symptom in the current situation. For these four factors we assign the corresponding weights $l_1, l_2, l_3, l_4,$ to obtain one Fuzzy set of weight allocations

$$\underset{\sim}{L} = (l_1, l_2, l_3, l_4).$$

When we assign a grade for each system according to the four functions considered above we get a graded Fuzzy set

$$\underset{\sim}{K}_{s_{m_j}} = (K^{l_1}_{s_{m_j}}, K^{l_2}_{s_{m_j}}, K^{l_3}_{s_{m_j}}, K^{l_4}_{s_{m_j}}), \ m = 1, 2, \cdots, 12, \ j = 1, 2, \cdots 4,$$

and

$$\mu_{m_j} \triangleq \max\{\underset{\sim}{K}_{s_{m_j}} \hat{+} \underset{\sim}{L}\}, \qquad (5)$$

where $\hat{+}$ is defined such that $a \hat{+} b = a + b - ab$.

The weight allocations are solicited from the experienced personnel. For a certain model aircraft the weight allocations assigned were

$$\underset{\sim}{L} = (0.4, 0.3, 0.2, 0.1).$$

For grades of concrete symptoms the first factor grade can be calculated directly from statistical material, that is $K^{l_1}_{s_{m_j}} = P(s_{m_j} | d_j) = \frac{N_{s_{m_j}}}{N_{d_j}}$, where N_{d_j} and $N_{s_{m_j}}$ are respectively the general frequency that cause type d_j produces a fault and the frequency of occurrence of symptoms S_{m_j} under these conditions. The second, third, and fourth factor grades can first be assigned respective degrees of subordination then later broken up corresponding to concrete symptoms. The degree of subordination for each factor on a certain model aircraft is give in Table 1.

Table 1. Degree of Subordination Corresponding to Symptom Language

	Mechanical analysis K'_2	Degree of manifestation K'_3	Ease of acquisition K'_4
$\mu_{d_j}(s_m) = 1$	must occur	very severe	very easy to observe
$1 > \mu_{d_j}(s_m) \geqslant 0.9$	extremely likely to occur	fairly severe	easy to observe
$0.9 > \mu_{d_j}(s_m) \geqslant 0.7$	very likely to occur	severe	observable
$0.7 > \mu_{d_j}(s_m) \geqslant 0.5$	could possibly occur	not very severe	fairly difficult to observe
$0.5 > \mu_{d_j}(s_m) \geqslant 0.3$	some possibility of occurring	slight	difficult to observe
$0.3 > \mu_{d_j}(s_m)$	some possibility of not occurring	very slight	very difficult to observe
$\mu_{d_j}(s_m) = 0$	impossible to occur	no change	unobservable

For example, when a certain model aircraft takes off the pressure increases slowly S_5, and the grade with respect to major pressure supply factor type fault d_1 is $\underset{\sim}{K}s_{5_1} = (0.8, 0.9, 0.3, 0.2)$. Thus from (5) the degree of subordination of this symptom with respect to cause type d_1 can be calculated to be

$$\mu_{s_1} = \max\{(0.4, 0.3, 0.2, 0.1) \overset{\wedge}{+} (0.8, 0.9, 0.3, 0.2)\} = 0.93.$$

Using the method above to calculate the degree of subordination μ_{m_j}, for each symptoms we can get a 12 row by 4 column cause type diagnostic matrix $R_d = (\mu_{m_j})$ and store it in a computer. This is the characteristic of the first mapping. When input is provided under the operation of this mapping we can obtain a specific output.

Set $P_j = (\mu_{1j}, \mu_{2j}, \cdots, \mu_{gj})^T$, $j = 1, 2, 3, 4$ the central determinant vector of the matrix. During diagnosis if we input the set of symptoms $S = (s_1, s_2, \ldots, s_{12})$ where

$$s_m = \begin{cases} 1, & s_m \text{ symptom appears} \\ 0, & s_m \text{ symptom does not appear} \end{cases} \qquad m = 1, 2, \cdots, 12,$$

then

$$\mu_{d_j}(S) = S \circ P_j = \bigvee_{s_m \in S} (s_m \wedge \mu_{m_j}). \tag{6}$$

Selecting $X_{d_j} = \max\{\mu_{d_j}(S);\ j = 1, 2, 3, 4\}$ the corresponding d_j is the diagnosed cause type.

3. Determining the characteristics of the second mapping

A certain aircraft model has 53 auxiliary symptoms and 64 cause locations. Exactly like the above the effectiveness or subordination function μ_{uv} is calculated for each symptom a_u with respect to a certain cause location k_v providing a 53 row by 64 column cause location diagnostic matrix $R_k = (\mu_{uv})$, to be stored in the computer. This constitutes the characteristics of the second mapping. For a fixed input, under the effect of this mapping we obtain an output of a certain cause location.

Considering that there are more symptoms (53) and the range of discourse of symptoms is $A = \{a_1, a_2, \cdots, a_{53}\}$, during diagnosis it is not possible in the current situation to provide simultaneously the conditions of 53 symptoms. It is only possible to provide a small portion of them; that is to provide a symptom set $A_0 = \{a_1, a_2, \cdots, a_q\}$, A_0 as a subset of A (the subscripts do not indicate the same elements as in A). Consequently it is not appropriate to utilize formula (6) above to calculate output. Instead we use the principle of greatest subordination to seek output. Make

$$\mu_{g_v}(A_0) \triangleq \frac{\mu_{1v} \cdot \mu_{2v} \cdots \mu_{qv}}{\sum_{v=1}^{53} \mu_{1v} \cdot \mu_{2v} \cdots \mu_{qv}}, \qquad (7)$$

using $\mu_{g_v}(A_0)$ to be the subordination function of the symptom A_0 with respect to a certain cause location K_v. Select

$$\mu_{g_j}(A_0) = \max\{\mu_{g_v}(A_0);\ v = 1, 2, \cdots, 53\} \qquad (8)$$

to be the output of the cause location K_j diagnosed by the input of A_0.

III. Automatic Interrogation Diagnosis Model

During diagnosis the diagnostic symptoms provided by personnel at the site can contain mistakes and omissions that make it difficult for computer diagnosis. Because of this it is necessary to equip the computer with the capability of preventative automatic questioning with respect to the most important symptoms for diagnosis so as to facilitate implementation of human-machine dialogue to promote correct diagnosis.

During diagnostic interrogation the machine acts as follows: Given an input of a symptom set $A_0 = \{a_1, a_2, \cdots, a_q\}$ if the calculated result produces

$$\mu_{g_j}(A_0) = \max\{\mu_{g_v}(A_0);\ j = 1, 2, \cdots, 53\},$$ make

$$s \triangleq \frac{\mu_{g_j}(A_0) - \mu_{g_i}(A_0)}{\mu_{g_j}(A_0)} \quad (i \neq j), \qquad (9)$$

and if $\varepsilon < \theta$ integration is necessary, where θ is the threshold value, $0 < \theta < 1$.

Determination of θ is as follows:

Select from experimental statistics a set of incidents (as many as possible, not necessarily typical incidents, due to the situation of possible mistakes and omissions in the statistics provided). For each incident the symtom set A_o and the cause location k_a are all known. Input A_o for computer calculation to get

$$\mu_{B_j}(A_0) = \max\{\mu_{B_i}(A_0);\ i = 1, 2, \cdots, 53\},$$

and if $k_j = k_a$ then consider the diagnosis correct. Conversely, if

$k_i = k_a\ (i \neq j),\ \mu_{B_j}(A_0) > \mu_{B_i}(A_0)$, then consider the diagnosis incorrect.

From formula (9) compute the corresponding ε value $(0 < \varepsilon < 1)$, select step size λ, then according to each small interval $(\varepsilon_i, \varepsilon_{i+1})$ statistically determine the diagnosis number N_i, set up the calculated general frequency as N_Σ, and make $P(\varepsilon_i < \varepsilon \leqslant \varepsilon_{i+1}) = \dfrac{N_i}{N_\Sigma}$ be the probability of correct diagnosis with respect to the compounding interval $(\varepsilon_i, \varepsilon_{i+1})$. Calculate the distribution function from the probability of correct diagnosis for every interval

$$F(\varepsilon) = P\{\varepsilon \leqslant \varepsilon_i\} = \sum_{\varepsilon \leqslant \varepsilon_i} P\{\varepsilon = q_i\},$$

Selecting the correct diagnosis probability α, then the corresponding value ε_i of $F(\varepsilon) = \sum_{\varepsilon \leqslant \varepsilon_i} P\{\varepsilon = \varepsilon_i\} = \alpha$ as determined to be the threshold value θ.

For example, for a certain aircraft model we select from experience 46 fault incidents, separately calculate their probability of correct diagnosis, and distribution function as shown in Table 2 (where $\lambda = 0.05$). Taking the correct diagnosis probability $\alpha = 0.14$, then $F(0.85) = 0.14$, therefore $\theta = \varepsilon_i = 0.85$ and when $\varepsilon \leqslant 0.85$ interrogation is necessary.

Table 2

ε_i	0~0.55	0.6~0.7	0.75	0.8	0.85	0.9	1
$P(\varepsilon)$	0.02	0.025	0.02	0.03	0.045	0.3	0.45
$F(\varepsilon)$	0.02	0.045	0.065	0.095	0.14	0.54	1

The kinds of symptoms which are queried depends on the most probable cause K_j obtained after input of the known symptom set A_o. That is the symptoms most useful to diagnosis cause K_j are queried.

Make the serial number set calculated under symptoms A_o be I. Then we get

$$\frac{\mu_{B_j}(A_0) - \mu_{B_i}(A_0)}{\mu_{B_j}(A_0)} \leqslant \theta \quad (i \neq j),$$

then in the two columns K_i and K_j calculate subordination function difference value $\mu_{r_j} - \mu_{r_i}$ which corresponds to symptoms in A_0 which did not appear in each row. Also pick $X_b = \max\{\mu_{r_j} - \mu_{r_i}; r \notin I\}$, then re-diagnose querying the corresponding symptom a_b.

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INVESTIGATION OF COLLIDING-MODE Nd:YAG LASER

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[Article by Lin Xing [2651 2502], Zhang Wenzhen [1728 2429 3741], Zhuang Huiming [8369 6540 7686] and Wu Fengtie [0702 6646 6993], Department of Physics, Huaqiao University, and Sun Zhan'ao [1327 0594 7663], Shanghai Institute of Optics and Precision Mechanics, CAS; manuscript received 5 February 1985, revised 23 March 1985]

[Text] ABSTRACT. The cavity configuration of a colliding-pulse mode-locked Nd:YAG laser is described. A stable mode-locked pulse train was observed with a 500-MHz oscilloscope; the average pulse width was about 10 ps. The relationship of the dye concentration to the mode locking threshold was studied in detail and mode-locked multiple pulses were shown to appear as the pumping energy was increased.

The colliding pulse mode [CPM] is a recently discovered mode-locking technique. In 1981, Fork et al. [1] first reported CPM operation in a ring dye laser, and in the last 2 years CMP operation has been achieved in Nd:YAG and Ar^+ lasers [3].

To achieve colliding-pulse mode locking in an Nd:YAG laser, we converted an SMG-1 mode-locked laser (produced by the Shanghai Institute of Optics and Precision Mechanics; see Fig. 1) into an antiresonant ring system as shown in Fig. 2.

Fig. 1. Contact-type reflective mode-locked Nd:YAG cavity

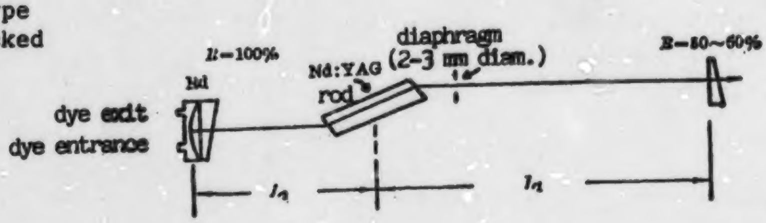
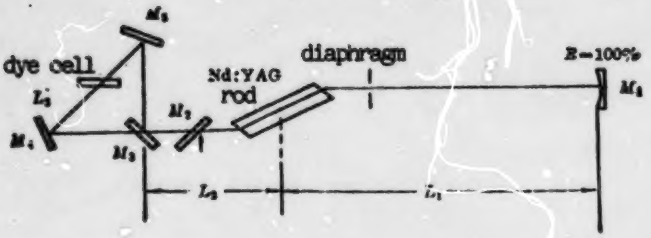


Fig. 2. Antiresonant ring CPM cavity



In Fig. 2, M_1 is a fully reflective mirror with Rd (radius of curvature) =3 m; M_2 and M_3 are semireflective (at 1.06 μm) dielectric-coated plates, M_4 and M_4 are dielectric-coated plates completely reflective at 1.06 μm, L_3 is the length of the antiresonant circuit, L_0, the total cavity length, is 1705 mm, the dye cell is placed outside the central interface of the ring cavity, and the dye used is pentamethine dissolved in 1,2-dichloroethane. M_2 not only serves as an output coupler, but also passes the mode-locked signal through an amplifying medium, providing one additional amplification of the output signal.

After adjustment of the optical circuit, a model 8801-21 photodiode was used as a detector at the output of lens M_2 and a 500-MHz oscilloscope was used to observe the waveform of the stable mode-locked pulse train, shown in Fig. 3. The conditions under which the photograph was taken were: 1000 V, 100 μf, dye transmissivity at 1.01 μm T_0 = 52.8 percent, cell thickness 1 mm, oscilloscope characteristics 200 mV/division, 20 ns/division, 10 repetitions per exposure. Under the same conditions, an SMJ-2 two-photon fluorescence pulse width meter was used to determine the pulse width, giving a result Δz = 1.67 mm (T_0 = 52.8 percent), from the equation $\Delta t_{TPF} = (\sqrt{2}\, n\Delta z/c)$ we found Δt_{TPF} = 10.4 ps. Measurements made under a variety of conditions indicated that when T_0 = 48-53 percent, the average mode-locked pulse width was 9-12 ps, about a third as wide as the 30-ps pulses obtained in the reflection method.

Below we investigate the relationship of the mode-locking threshold to the transmissivity, thickness and concentration of the dye solution.

1. Choice of Saturable Absorber Thickness

The relaxation time T_r of the dye, its concentration, and the dye cell thickness l are important parameters in obtaining shorter, more stable passive mode-locked pulses; they must meet the condition [4]

$$(2nd/c) < T_r \qquad (1)$$

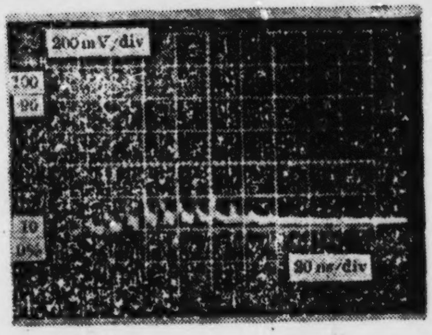


Fig. 3. Pulse train of colliding-pulse mode-locked Nd:YAG laser

For the solution of pentamethine dye dissolved in 1,2-dichloroethane that we used, T_r was 10-30 ps; for T_r = 20 ps and n = 1.45, d must not exceed 2 mm (where d is half the penetration length of the pulse in the dye solution, and for a transmission-type CPM structure d = $\ell/2$). Thus the effective length of the dye cell in the cavity must not exceed 4 mm. We used a dye cell 1 mm thick, which when placed at the Brewster angle had an effective thickness of 1.5 mm. If the thickness of the dye is equal to or less than the pulse length, there will be a clear-cut instantaneous grating effect. In practice, the dye cell requirements limited the small-signal transmissivity range, because stable operation occurs only when the loss per unit path length is less than 1.

In our experiments we generally used a dye cell thickness of 1 mm; the transmissivity of the two dye cell lenses to weak 1.06-μm light was 90 percent.

2. Preparation of Required Saturable Absorber Concentrations

With constant dye cell thickness, we discovered that the transmissivity of a freshly prepared dye solution was unstable. When measured the day after preparation, the small-signal transmissivity always showed an increase. Once this value had stabilized it would be maintained for several days. After stabilization, the required transmissivity could be achieved in accordance with the equation

$$T_0 = \exp(-\alpha_0 l/M), \qquad (2)$$

where α_0 is the linear absorption coefficient of the original dye solution (in our case, 5 mg of pentamethine dissolved in 10 ml of 1,2-dichloroethane), ℓ is the thickness of the dye cell, and M is the dilution factor. We used a model 751 spectrophotometer to determine the standard value (λ = 1.01 μm). Thus, by preparing a solution and determining T_0 (defined as the transmissivity of the dye, with the transmissivity of the dye cell subtracted from the measured value) and calculating α_0, equation (2) can be used to determine the dilution factor M needed to give the desired value of T_0. The calculation results showed good agreement with the standard values. For α_0 = 120 cm^{-1}

and M = 16, we obtain $T_0 \approx 52$ percent (for m = 1 mm), in agreement with the standard values).

3. Relationship of Mode-Locking Threshold to Dye Transmissivity

a. For a Given Dye Solution Thickness

To investigate the relationship of dye transmissivity to mode-locked lasing and stability [as published], we prepared several dye solutions with different transmissivities (i.e., concentrations) in accordance with equation (2). In our experiments we found that each concentration had a clear mode-locking threshold and that when the pumping energy was increased by a certain amount, multiple-pulse mode locking occurred; the results are shown in Table 1 and Fig. 4.

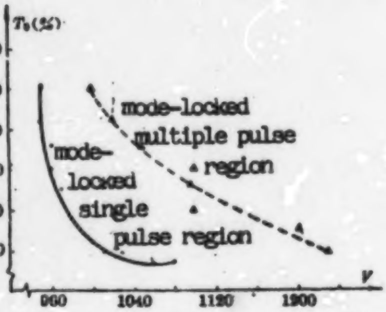


Fig. 4. Dye concentration versus mode-locking threshold

Table 1. Mode locking at various dye concentrations (Circles indicate single-pulse mode locking, triangles indicate multiple-pulse mode locking)

Voltage V / Transmissivity T_0	950	960	970	980	1000	1010	1020	1050	1080	1100	1120	1150	1180	1200	1220	1230
36.9%									○	○						
40.1%						○	○	○	○	○	○	○	○	○	○	△
46.1%					○		○	○	○	○	○	○	○	△	△	
50%		○		○	○			○	○	△		△				
55%			○		○			○	○	△		△				
59.9%		○		○	○		○	○	○	△		△	△	△	△	
66.1%		○		○	○		○	△	△	△	△	△	△	△	△	
72%	○	○		○	○		△	△								
80.5%	○	○		○	△		△									

In our experiments, the mode-locked pulse train was most stable when T_0 was about 50 percent; the peak value was then high and the single-pulse mode-locking region was at its broadest. When the concentration was increased, the mode-locking threshold rose and the output energy increased, but damage to the components was likely.

It can be seen from Fig. 4 that when the value of T_0 for the dye was 50 percent or more, the pumping threshold for mode locking was almost constant, but multiple pulses appeared earlier and the single-pulse mode locking region contracted as the dye concentration was decreased. Our experiments showed that when the pumping energy was increased to a certain value, single-pulse mode locking was replaced by multiple-pulse mode locking.

b. For Approximately Constant Transmissivity

For different dye cell thicknesses, we prepared dye solutions of different concentrations in order to achieve approximately equal cell transmissivities, then determined the mode-locking thresholds. The results are shown in Table 2.

It can be seen from Table 2 that for different dye cell thicknesses but approximtely equal transmissivities (i.e. with the thickness decreasing as the concentration increased), the mode-locking thresholds were approximately constant, indicating that for constant transmissivity, within a certain range the dye cell thickness has little effect on the mode-locking threshold.

Table 2. Relationship of cell thickness to mode-locking threshold for approximately constant transmissivity

Dye cell thickness l (mm)	1	1.5	2	2.5
Dye transmissivity T_0	50%	48.1%	51.4%	48.4%
Mode-locking threshold (V)	960	990	960	970

These experiments indicate that the mode-locking threshold is determined by the transmissivity of the dye solution and that different mode-locking thresholds can be achieved by varying the concentration and thickness of the dye solution; thus it is possible to vary the power of mode-locked pulses over a certain range.

4. Stability of Colliding-Pulse Mode Locking

In analyzing passive mode-locking cavity configurations and cavity parameters, we worked primarily with the TEM_{00} mode, and the mode-locked pulse trains were stable. The stability parameter S is defined as

$$S-K(\sigma_a/\sigma_g), \tag{8}$$

where K is the ratio of the beam area at the amplifying medium to the beam area at the absorber; this is generally a constant larger than 1. When σ_a is the absorption cross section of the saturable absorber and σ_g is the amplification cross section of the amplifying medium, $(\sigma_a/\sigma_g) \gg 1$, so that the stability increases with increasing K.

a. Contact-Type Reflective Cavity

In the SMG-1 contact-type reflective cavity shown in Fig. 1, the dye cell is in close contact with the concave-back completely reflecting mirror (Rd = 3 m). This configuration uses the smallest components and there is no subcavity; the stability is somewhat better than for the non-contact type of cavity. Its deficiencies are: it is difficult to machine the composite dye cell; the concave reflector is difficult to replace if it is damaged, and the optimum radius of curvature Rd for the mirror is related to the refractive index of the dye [5]; and when the mirror is close to the dye it is likely to be affected by heating of the dye, with the result that the beam area in the absorbing medium will increase. For this configuration, $K < 1$.

b. Antiresonant Cavity

The antiresonant cavity shown in Fig. 2 is rather complex, but it has the advantage that the dye cell is easy to make. Provided that the dye cell is placed at the Brewster angle, subcavities are prevented, and under our experimental conditions the requirement regarding centering of the dye cell was not very strict: a deviation not exceeding ±2 mm has little effect on the output. For this cavity, $K > 1$, resulting in good stability. If M_4 and M_5 are changed to small-curvature completely reflective mirrors, the spot size in the saturable absorber can be further decreased, thus increasing K, and the dye cell can be distant from the concave fully reflective mirror, whose radius of curvature will not be affected by heating of the dye.

The equivalent optical path length of this cavity is $L_0 = L_1 + L_2 + (L_3/2)$, and the optimum radius of curvature for the concave mirror is subject to the condition [5]

$$4\left\{\left[2\frac{L_0}{L_1}+1\right]-\left[2-\left(2\frac{L_0}{L}-1\right)^2\right]^2\right\}^{-1} L_0 < R < 2L_0. \qquad (4)$$

In equation (4), provided that $[2(L_0/L) - 1]^2 \leqslant 2$, there is a real solution; the position of the rod must be such that $(L_1/L_0) = 5/6$. This can be achieved by shortening the ring length, so that the rod is as close as possible to the semireflective beam splitter.

In Fig. 2, if M_2 is absent, a new cavity configuration results, in which there is an output at M_3, but this configuration gives a rather small output energy, and the optical components are likely to be damaged. When M_2 is added, because an additional amplification stage is introduced, the output energy is increased and the directionality and stability are improved.

Using a 500-MHz oscilloscope, we observed stable mode-locked pulse trains from the antiresonant cavity; the average pulse width determined with a two-photon fluorescence pulse width meter was about 10 ps. We analyzed the factors affecting passive mode-locking stability. The experiments showed that CPM operation had a distinct threshold and that the range of stable operation was rather wide. We investigated in detail the relationship of the CPM threshold to dye solution thickness, concentration and transmissivity. Multiple-exposure photographs indicated that the mode-locked pulse train stability was rather high and that the repetition rate was rather good. The dye cell in the CPM system was easy to fabricate, and replacing the cells and measuring the dye concentration were easy and economical, allowing repetitive operation. In addition, partial mode locking was also observed on the oscilloscope when a BDN dye film (0.1 mm) was used as a saturable absorber, indicating that the CPM system is favorable for passive mode-locked operation.

We believe that the relationships between various parameters of the Nd:YAG CPM system should be investigated further and that the optimum mode-locking conditions should be found in order to obtain even narrower pulses.

Other participants in the work included Comrades Zheng Yunshan [6774 0061 1472], Dai Jinlong [2071 6855 7893] and Zhuang Jinchuan [8369 6855 1557].

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MAJOR EFFORT PRODUCES BETTER MARINE ENVIRONMENT PROTECTION

OW010254 Beijing XINHUA in English 0236 GMT 1 Mar 86

[Text] Beijing 1 March (XINHUA)--Since China promulgated the Marine Environmental Protection Law on 1 March 1983, there has been a marked improvement in the waters around China's coasts, according to the State Bureau of Oceanography here today.

The bureau is now holding a meeting on marine environment in Beijing to further enforce the law for marine pollution control.

Over the past few years China has established a national marine pollution monitoring network with 236 observation posts along the coast, collecting a huge amount of data on sea water, sediment and marine biology.

Last year, the bureau sent ships on over 200 patrol missions and planes on 70 missions to monitor the pollution in the country's territorial waters. It also handled the illegal dumping of pollutants in the sea by Chinese and foreign ships and oil platforms according to the law.

The monitoring has proved that the environment in the oil-polluted Bohai Sea in North China has improved and heavy-metal pollution in the coastal sea waters reduced.

A leading official of the bureau told the meeting that although much progress has been made in marine environmental protection, illegal dumping of pollutants into the sea still takes place.

He said this year his bureau would put more teeth into the marine protection law by organizing more ships and planes to monitor the marine environment and deal seriously with cases of marine pollution.

The bureau, he said, will also work out regulations concerning waste dumping along the coastal areas, and patrol the country's fishing grounds to safeguard China's marine rights and protect fisheries.

Aerial remote-sensing technology will be applied to the marine environmental monitoring this year, he added.

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ENVIRONMENTAL QUALITY

CHINA DRAWS UP EMERGENCY PLANS FOR MARINE POLLUTION

OW031222 Beijing XINHUA in English 1203 GMT 3 Mar 86

[Text] 3 March Beijing (SINHUA)--China has completed its study on prevention, control, and response to marine pollution, and is drawing up an emergency response plan for such pollution, an official of the State Bureau of Environmental Protection said here today.

Sun Jiamian, deputy director of the bureau, said that besides this national contingency plan, China will also work out regional emergency plans, plans for bays and harbors, and for offshore oil exploration and exploitation, as well as conclude agreements with neighboring countries.

Sun made these remarks at the opening ceremony of a week-long workshop on marine pollution prevention, control, and response jointly sponsored by Chian's Ministry of Communications, the State Bureau of Environmental Protection and the International Maritime Organization.

Sun said that quite a few oil spills had occurred in Chinese waters over the past few years and had caused damage to the country's marine biological resources, tourism, and various economic and social activities with considerable economic losses.

The Chinese government, he said, attaches great importance to marine environmental protection and has promulgated the Marine Environment Protection Law and administrative rules and regulations.

The country has established organs for marine administration, built up an "army of specialists," and strengthened supervision and control of marine pollution.

Sun said that China hopes to increase its contacts and exchanges with relevant international organizations.

Seven specialists from the International Maritime Organization attended today's opening ceremony and will give lectures to about 100 professionals from all over the country.

Ramesh P. Upadhyay, deputy resident representative of the United Nations Development Program, and [word indistinct] of the Chinese Ministry of Communications were also present at today's meeting.

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STUDY OF X-RAY PREIONIZED XeCl EXCIMER LASER

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 5 No 5, Oct 85
pp 201-203

[Article by Tang Shiqing [0781 1102 3237], Yuan Yifeng [5913 0001 7364], Deng Huihua [6772 1920 5478], and Ding Ze'an [0002 3419 1344] of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Abstract] In ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS], Vol 10 No 3, 85 p 152, the authors reported experimental results of excimer laser by using spot light source X-rays as the preionization source. In order to increase equipment service life with a compact structure, the authors used large-area cold-cathode transmission-type narrow-pulse (less than 200 ns) X-rays as the preionization source, and the conventional C804 capacitor instead of the panel transmission line; a better effect was achieved. The effects of charge voltage and discharge time delay on the puncture voltage, rate of rising discharge voltage, output light-pulse energy and equipment efficiency as well as the laser output have been studied for a modified X-ray preionized XeCl excimer laser. The delay characteristics curve of 0-700 ns was given in one of seven figures. Six other figures show the experiment setup, discharge voltage waveforms, as well as charge voltage on the one hand, and laser pulse energy, rate of rising discharge voltage, laser output and equipment efficiency on the other. The paper was received for publication on 1 February 1985.

IMPROVEMENT OF KrCl EXCIMER LASER

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 5 No 5, Oct 85
pp 204-206

[Article by Jiang Baocai [5592 1405 6299], Leo Yuekang [2867 6460 1660] and Yuan Cailai [5913 2088 0171] of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, and Zhang Yibin [1728 1837 1755] of Northeast Telecommunication Engineering College]

[Abstract] For the excimer laser to be practical, there should be compact equipment with reliable performance and low cost. In this paper, an ultraviolet (UV) preionized discharge excited KrCl (λ=222 nm) excimer laser with concentrated-parameter ceramic industance-free capacitance is reported. The single-pulse output energy is over 63 mJ. In four of nine figures, experiments show that the output energy of the KrCl excimer laser is closely related to charge voltage, total gas pressure, and Kr content. Five other figures show transfer and equivalent circuits of a capacitor, testing setups for energy measurement and voltage waveform, far and near field output laser spots, and a voltage waveform curve. The paper was received for publication on 28 March 1985.

OUTPUT CHARACTERISTICS OF CASCADE ULTRASHORT CAVITY DYE LASERS

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 5 No 5, Oct 85
pp 207-210

[Article by Liu Yixian [0491 0001 0341], Wu Changzheng [0124 7022 2973], Zhu Xiaoxiong [2612 1420 7160], Sun Weiyong [1327 0251 0516] and Li Fuming [2621 1381 6900] of Departments of Physics, Fudan University]

[Abstract] In this paper, the dependence of output spectral characteristics of a cascade short-cavity dye laser on pumping wavelengths and concentration of dyes is reported. The experimental results are also described: a second harmonic nanosecond pulse from a Q-switch ruby laser converted into a tunable subnanosecond pulse by a transient technique of a Roess-Lin resonator. As shown by experiments, the cascade pumping ultrashort-cavity operation style can extend the tuning range of the light spectrum, and obtain light pulses compressed to picoseconds. If operated with a multistage cascade pumping method, ps (the limit of photon lifespan in a cavity) light pulses can be obtained from ns pulses. Eight figures show the experimental setup, output light spectra of cascade ultrashort cavity, light pulse waveforms of various-stage outputs of cascade ultrashort cavity, relationship between laser output spectra and cavity length, relationships between laser output central wavelength and increment bandwidth on the one hand, and pumping light wavelength and dye concentration on the other, relationship between laser tuning wavelength and piezoelectric ceramic voltage, and the relationship between dye laser pulse width and output power on the one hand, and the power of pumping light on the other. The paper was received for publication on 17 March 1985.

FLASH PUMPED PICOSECOND DYE LASER

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 5 No 5, Oct 85
pp 211-212

[Article by Wang Shuicai [3769 3055 2088] and Shi Ke [0670 3784] of Xian Institute of Optics and Precision Mechanics, Chinese Academy of Sciences]

[Abstract] A high efficiency flash pumped picosecond dye laser is described. A 1.5 x 10^{-4} M R 6G is used as the lasing medium; a 1 x 10^{-4} M DODCI is used as the mode-locked dye. Laser pulses with duration of 2-5 ps and power of megawatts at a wavelength of 580-620 nm can be obtained. The output of the flash pumped ps dye laser is sequence pulse with pulse width narrower and narrower along with sequence to 2 ps as the narrowest pulse width. The authors used a BWS-5K image changing tube ps scanner to measure the laser pulse with its setup shown in one of five figures. The mode-locked pulse sequence is shown in another figure while its sequence envelope is shown in a third figure. The laser pulse was obtained with a model BWS-5K image changing tube ps scanning camera. The remaining figure shows the principle of the experimental setup for a flash pumped ps dye laser. The paper was received for publication on 2 April 1985.

OPTIMUM CHARGE OF SOLID-STATE PULSED-LASER POWER SUPPLY

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 5 No 5, Oct 85
pp 223-224

[Article by Ning Xifa [3942 0823 4099] and Yao Jianquan [1202 1696 6898] of Department of Precision Instruments Engineering, Tianjin University]

[Abstract] The optimal charge process is analyzed for raising charge efficiency. The optimal charge time is formulated for a practical charge circuit. Mathematical equations are derived for analysis of the optimal charge process and time: heat loss in the circuit, energy loss at constant-current charge, circuit current, total loss during charge period, minimum loss during optimal charge time, and the charge efficiency. The only figure shows a charge circuit for constant-current power source in order to adjust the voltage as the optimal output voltage within a charge period by raising the charge efficiency. The paper was received for publication on 7 March 1985.

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China Report

SCIENCE AND TECHNOLOGY

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SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

BEIJING'S 1985 S&T ACHIEVEMENTS REPORTED

OW121113 Beijing XINHUA in English 0900 GMT 12 Feb 86

[Text] Beijing, 12 February (XINHUA)--Some 2,400 scientific and technical achievements were made last year in China's capital, according to today's BEIJING DAILY.

Three quarters of the achievements have been applied to production and have added 207 million yuan to production.

Seventy won national invention awards in 1985, the paper said.

Last year brought the city the greatest number of scientific and technical achievements and the best economic results, it noted.

Helping make research results commercially viable and serve the nation's economic development with technical know-how was China's first national technical trade fair held here last May. At it, the city displayed 3,200 achievements and ranked 2nd in business volume of China's 29 provinces, municipalities, and autonomous regions.

The city has also established 508 various economic undertakings to increase links between academic research and production.

Last year, 379 key technical transformation items were completed and put into production, creating 1.7 billion yuan a year in production value and bringing Beijing an increased 247 million yuan in profit.

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HUNAN'S 10 MAJOR SCIENTIFIC ACHIEVEMENTS IN 1985

Changsha HUNAN RIBAO in Chinese 3 Jan 86 p 1

[Text] To encourage groups and individuals to make vital contributions to scientific and technical advance in the province, the provincial Science and Technology Commission has named Hunan's 10 major scientific and technical achievements for 1985 after consulting the departments concerned. The achievements are:

1. The Milky Way digital simulated computer and the Milky Way super microcomputer. The birthplace of China's first Milky Way -- the National Defense Science and Technology University -- has again researched and manufactured the Milky Way digital simulated computer and the Milky Way super microcomputer, which are of the highest international standard of the early 1980's. Their successful creation has tremendous economic and military significance.

2. Human high-resolution chromosome technology and its application. In a development that marks the entry of human cell genetics into a new stage, the Hunan Medical College has discovered a new technique to make and identify chromosome samples - human high-resolution chromosome technology. Its research in the manufacture, identification and application of high-resolution chromosome samples is a leader in the nation and on a par with the world.

3. Biliary passage. The No 1 Hospital attached to the Hunan Medical College has come up with a new kind of biliary passage surgery. Advanced, scientific and practical, this research is unprecedented in the country and has reached international standard.

4. Crucian carp crossbreeding research. A cooperative project between the Donghu Fish Farm in Xiangyin County, the Biology Department of the Hunan Normal University and the Hunan Marine Research Institute, crucian carp crossbreeding research produces outstanding economic results as well as being an academic breakthrough in basic theory. It is in the forefront of such research domestically and abroad.

5. Satellite remote-sensing applications research in the Lake Dongting area. Assigned by the State Science and Technology Commission, this project on "satellite remote-sensing in Lake Dongting" was brought to a successful end

through the joint effort of a dozen or so units, including the Hunan Economic and Geographic Research Institute and the training section of the National Remote Sensing Center. This piece of research is a pacesetter at home, with aspects of it reaching international level.

6. The regionalization of ramie varieties and its high-speed asexual reproduction. The Ramie Research Institute of the Hunan Academy of Agricultural Sciences and the Cash Crops Bureau of the provincial Agriculture Department successfully came up with a process to regionalize ramie varieties and produce it asexually fast. This achievement is both a domestic and international innovation.

7. Heavy-metal marine environment capacity research in Xiangjiang. Designated by the state as a key research project in the "Sixth 5-year Plan," heavy metal marine environment capacity research was undertaken and completed by the Hunan Environmental Protection Research Institute. It opens up new terrain in environmental science. Its achievements are the most advanced at home and, in some respects, in the world.

8. A method to grade the drillability of rock. Invented by the Changsha Mining Research Institute, this method makes possible on-site testing using irregular core samples and is convenient, fast, and inexpensive. It provides a feasible technique for determining the character of the rock on the spot, setting labor quotas and implementing scientific management. The research achievement has reached international level.

9. DC16-4 high-pressure direct-current circuit insulator. This insulator, the result of joint research between the Lujiang Electric Ceramics and Electric Appliance Co and the Electric Science Research Institute of the Ministry of Water Resources and Electric Power, filled a technical void in China. Its leading technical indicators show that it has achieved the level of comparative products abroad.

10. QT80A self-rising tower crane. The first self-rising crane made in China, the QT80A vastly enhances our ability to put up high-rise structures. The machine has an original design and, according to its leading technical indicators, is among the most advanced similar products in China.

12581
CSO: 4008/2061

BEIJING PARTY SECRETARY ATTENDS FORUM OF RESEARCHERS

SK270147 Beijing BEIJING RIBAO in Chinese 7 Feb 86 p 1

[Text] Beijing Municipality has very favorable scientific and technological conditions. It is necessary to better display this condition through technical cooperation in order to promote the four modernizations in the capital. The above statement was given by Mayor Chen Xitong at a forum of responsible persons of some central scientific research units, colleges and universities in Beijing.

Comrades Li Ximing and Jiao Ruoyu showed their agreement with Chen Xitong's opinions by nodding frequently. Jiao Ruoyu said in particular that in reforming the scientific and technological system, we must break with the shackles and restrictions between departments and regions and carry out more lateral cooperations.

Last year our municipality scored great achievements in carrying out scientific and technological cooperation. The central scientific research units and colleges and universities in Beijing have exerted very great efforts and scored achievements in a great number of scientific and technological findings, playing a very good part in promoting technical progress among enterprises in the municipality. The responsible persons of 31 councils from the Beijing scientific and technological coordination center expressed their determination that they will actively carry out technical cooperation and exert efforts in the construction of the capital.

Comrades Lu Yucheng and Zhang Peng introduced the relevant situation of Beijing to the participants. The responsible person of the municipal Economic Commission gave an account of the numerous new tasks of the enterprises under the municipal Economic Commission.

/12712
CSO: 4008/2068

NATIONAL DEVELOPMENTS

VALUE OF SCIENCE, DEVELOPMENT OF COMPUTERS DISCUSSED

Beijing KEXUE GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 4, Oct 85 pp 10-12, 6

[Article by Hong Jiawei [3163 0502 1218] of Beijing Computer Institute: "The Value of Science - and Development of Intelligent Computers"]

[Text] Science has application value, market value, and labor value. These are different values which are discussed in the following:

1. Application Value

In terms of application value, science and technology is productivity. Its effect on pushing mankind forward cannot be calculated in value. In other words, an estimate cannot be placed on science and technology.

The force to push human society forward is the productivity development and evolution of relations of production. The most effective, active, and determining factor, however, is the development of productivity. Productivity development is after all a result of progress in science and technology. Scientific and technological accomplishments reflect man's understanding and ability to harness nature. It shows the subjective activity of mankind. A review of our long history reveals that development in science and technology is the most profound reason for mankind to evolve from a primative society to the electronic world.

Of course, as a whole, science and technology is priceless. Not every technical achievement, however, is always priceless. Even major technical achievements which have a determining effect on the lives of mankind are priceless with respect to infinite time. Within any finite time period, the application value of any technical accomplishment is limited. Hence, we have to assign priorities.

Due to various complicated reasons, in the past some of our technology was not linked to economic construction. Therefore, the present economic reform requires many comrades to change their directions. Our experience shows that scientists with some theoretical background have the ability to undergo such a change to contribute significantly to economic construction. In addition, profound problems may be solved in practice.

In the following we will discuss a specific problem with strategic significance; i.e. the development of intelligent computers. Is an intelligent computer a priceless treasure? Is it worthwhile pursuing?

Computer has been around for 39 years. It is influencing the whole world and has penetrated into major territories in the human society. It plays the role of steam engine in the new technological revolution. Up till now, however, the development of four generations of computers has mainly relied on the improvement of components. There are fundamental defects in the system structure. Computers cannot process knowledge and perform logic deduction. They are also unable to conduct a dialogue with man in any natural language. Therefore, there must be a basic breakthrough in computer development. A new generation of computers--intelligent computers--will emerge.

The main special feature of such a new computer is that it will be able to process knowledge and perform logic deduction just as human beings. It can understand Chinese and work as a secretary. For instance, it can search technical literature, manage business and factory, take care of acres of land as an experienced farmer, educate children at home, do house chores and care for the elderly. By then our productivity will be significantly improved. Science and technology will move forward at a much faster pace. Human life will change drastically.

The intelligent computers, just as microcomputers today, will dominate the market. The Japanese believe that in the 1990's the world will be dependent upon intelligent machines just as we were on oil from the Middle East in the 1970's.

Surveillance systems, coding systems, intelligence systems, command systems, and controls systems in defense cannot survive without intelligent computers. Intelligent weapons will make most advanced weapons in the 1980's look like spring-wound toys.

To this end, leadership in the development of intelligent computer will result in a leading position in the economy, science, culture and defense. Intelligent computer is truly a priceless treasure.

2. Market Value

Although science is a priceless treasure, it is a pity that it does not have a market value (i.e. exchange value). At least up till now science is not a piece of merchandise and cannot be sold in the market. It simply does not have any market value. How much money can the laws of Newton or Einstein's theory of relativity be worth? None. Technology is different. It may become products or patent rights. For instance, computer softwares may become true commercial products after resolving certain problems.

The reason that science is not a piece of merchandise, at least as of yet, is because of the following major reasons. First, scientific results are usually some information which are summaries of laws governing the nature and the development of a certain object. It is very difficult to achieve it for the first time, but very easy to propagate it. It is very hard to keep it a secret. For instance, everyone knows that the ratio of the circumference of a circle to its diameter is $\pi = 3.1415926$ and can make use of it. There is no way to patent it. It is also not possible to demand a royalty from people who use it. Second, the application value of scientific results usually lasts longer and the effect is more indirect. A scientific principle must rely on technology to transform into productivity. Hence, scientific accomplishments cannot bring immediate benefits to a individual or organization. Third, many technical accomplishments are based on the same scientific principle. Thus, scientific achievements, by nature, benefit the public. Individuals or organizations should not be asked to support it alone. The study of intelligent machines belongs to this category.

The sharp contradiction between the infinite application value and the lack of market value can only be resolved by government support of scientific efforts. For example, the development of intelligent computers can be listed as a focal item under which special policies apply. It is supported by a science foundation. If the government does not support it, under the circumstance that profit and service are stressed (which is necessary for the overall picture), this long-term research project may be bumped, resulting in unmeasurable loss. Because of the high rate of reeducation, there are very few people in China qualified to develop intelligent machines. Moreover, they are mostly lower paid young and middle-aged people whose bonuses will be affected because the development of intelligent computers cannot bring in immediate profits. If they give up this difficult task and perform ordinary technical work, their income will immediately increase by several folds. We have people with Ph. D. degrees giving up research to become businessmen. This situation makes the development of intelligent computers difficult to continue. In some places, the people involved in business get the largest cut. People engaged in development get the middle cut and the design people get the small cut. If we do not pay attention to this situation, medium- and long-term research projects will be strongly impacted.

Several years ago we went into the rural areas to help in harvesting. I used to sharpen sickles for everyone because I could do it fast and well. However, those who cut the most wheat received recognition, instead of me or the person who taught me how to sharpen the sickle. This demonstrates that work behind the scene is not recognized. Technical exchange is the same situation. Some comrades feel that several million yuans spent by the National Science Commission in technical exchanges are wasted. They believe that it is not very useful to hold so many academic meetings. They do not know that the exchange of scientific information and thinking is absolutely required. Its effect cannot be judged in terms of money. Many journals are economically difficult to sustain. Our academic exchange is held to a minimum. Obviously, education is also done behind the front line. Our education budget is too small in the national economy and the teacher's pay is too low. These are problems that have to be overcome.

To make the economy scientific and to economize science is a correct policy. When implementing this policy, however, we not only must serve today's economy but also must serve tomorrow's economy. Therefore, we should properly proportionate among the first, second, and third lines. The leaves of a tree produce nutrients on the front line. A portion of the nutrients is consumed there. Another portion is delivered to the root through the bark which sends water and minerals to the branches through the xylem. If the leaves are too selfish, it will lead to serious consequences. There is no harm if we experiment a little. If the bark is peeled, the tree initially appears to be flourishing. However, it will die very shortly. Of course, this is an extreme case. We should not go to extremes. We should also pay attention to the fact that Chinese computer professionals are attracted by an economic force to work on adding Chinese characters to foreign made microcomputers to be later dumped into the domestic market. On the long run, the technical gap between China and other advanced countries will widen. We will become a technical colony. This is an alarming trend. We should immediately organize ourselves to take protective measures to make intelligent machine a national key issue to improve the standard of Chinese computer technology.

3. Labor Value

The labor value of science exists. It is finite and can be calculated. Marx believed that the value of a product is the average social labor required to manufacture it. When he talked about the compensation of workers in a capitalist society he said that the compensation should support the livelihood of the worker. Furthermore, it should enable the worker to receive the education and rest to maintain his job and to allow him to bring up a family. In summary, the compensation is a cost to allow him and his descendant to continue working as laborers. This cost is far less than the value of the product. The difference is called surplus value.

According to the principle of Marxism, the labor value of knowledge should at least be equal to the cost to ensure that an intellect can continue to produce intellectual products. These conditions are:

(1) Study and research conditions. In order to perform scientific research, a person must attend grammar school, high school, and college. Some even studied for their master's and doctoral degrees. Science and technology changes ever so rapidly and the pace of reeducation is so fast. Some disciplines existed for a dozen years. A expert's skills might become obsolete in 4-5 years if he does not absorb new information in his field. Therefore, they should have the opportunity to study and exchange information. They should be given the necessary conditions to perform experiments, as well as quiet offices and studies.

(2) Comfortable living conditions. The work of a scientist is a life-long race. His time is very valuable. If we want him to take the lead, we should not allow him to waste his time on doing household chores and waiting for crowded buses.

Only with these conditions can an intellect remain an intellectual and continue to produce intelligent products. The price to pay to ensure these conditions is very limited. The labor value of science is far more than this cost. We should be willing to pay this small price for a priceless treasure. Policies should be implemented to organized qualified people to develop intelligent computers.

In order to assure intellectual work, the conditions described above are not sufficient. We should also have good social conditions, including firm leadership and long-term support. In addition, we need close collaboration from all personnel concerned. Without such social conditions, the research will run into obstacles.

The three types of values of science are discussed above. However, money is not the only thing in science. There should also be some dedication. The development of intelligent computers concerns the future of our nation. At present, some developing nations are just starting because it is an unique opportunity. Japan mobilized 40 "scientific warriors" to work on an ambitious 10-year Plan and who have sworn to succeed. In the development of intelligent machine, if China also concentrates its talents, develops a plan and works hard, we should not be too far behind other countries. It would be possible to obtain some useful results in a short period of time. If we hesitate, we will regret later. With regard to this important issue, we should be determined to re-enter the leading role in science and technology in approximately 15 years.

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CSO: 4008/1029

NATIONAL DEVELOPMENTS

GUANGZHOU'S DEVELOPING TECHNOLOGY MARKET

Guangzhou NANFANG JINGJI [SOUTH CHINA ECONOMY] in Chinese No 5, 85 pp 35-37

[Article by Zhang Jinzhi [1728 6930 2535]: "The Rapid Growth of Guangzhou's Technology Market in Recent Years"]

[Text] Major Forms of the Guangzhou Technology Market

The technology market in Guangzhou has been growing very rapidly in recent years. As reform and the open door policy develop in depth, in particular, technical trade has become an important part of the socialist unified market. At present, technical trade in Guangzhou mainly takes the following forms:

(1) Software market. Information is disseminated and ties established primarily through all kinds of academic seminars, public lectures, data circulation and consulting services. More specifically:

1. organizing a variety of technical and academic lectures and technical training courses. As a preliminary form of the technology market, they cover a broad area and are relatively widespread. The Guangdong and Guangzhou science and technology commissions alone have organized more than 700 lectures on advanced foreign technology and other academic subjects in recent years, attracting over 80,000 attendants from all over the country. Since 1980, the Guangzhou Science and Technology Exchange Clearinghouse, in cooperation with scientific and technical personnel from Hong Kong, Macao and other parts of the world, has conducted 60 courses of all types (including foreign languages and management) with a combined enrollment exceeding 11,600. The Guangzhou Chinese Medical College began offering international acupuncture courses in 1980 which have drawn a total of 300 students so far from 45 nations and regions, including Japan, the United States, and Australia.

2. developing all kinds of scientific and technical consulting and gradually putting together a citywide scientific and technical consulting network made up essentially of academic institutions supported by technical consulting organizations in various departments. According to incomplete data, there are now 81 assorted technical consulting research institutions, consulting service centers, consulting service companies and consulting service agencies in Guangzhou. The scope of consulting includes the import of technology,

equipment and capital; investments; the development of new products and new technology, and business, etc. In 1984 more than 1,000 consulting projects were launched, boosting economic results by more than 10 million yuan.

3. sending scientific and technical personnel abroad on study and exchange missions. In recent years, the provincial and municipal science and technology commissions dispatched 40 missions involving 2,000 people to Japan, the United States, Australia, Hong Kong and Macao for study purposes. At the same time, the municipality played host to 400 groups consisting of 2,000 foreign visitors from the scientific and technical community who stopped over at Guangzhou during their China tour.

4. disseminating information through the press, periodicals and journals. Between them, the Guangdong provincial Science and Technology Publishing House, major colleges and universities, research units and academic organizations put out 300 specialized journals and miscellaneous publications and millions of copies of books a year. The Guangdong provincial Science and Technology Library, Zhongshan Library, Guangzhou Library and the libraries of various colleges, universities and research units subscribe to over 10,000 journals in science and technology and have several million science and technology books in their holdings. The Guangzhou branch of the China National Publications Import Corporation has established long-term business relations with 8,000 publishers, book dealers, and academic research organizations in more than 100 nations and regions and provides scientific and technical publishing services both inside and outside the province.

(2) Hardware market. Technical exchange is mainly effected through all manner of scientific and technical achievement exhibitions, seminars and brainstorming sessions to tackle a particular technical problem jointly. Specifically:

1. The hallmark and chief organizational expression of the Guangzhou technology market is scientific and technical achievements exhibitions, exchanges and fairs of every description. The first scientific and technical achievement exhibition and exchange in the Guangzhou area was held in 1982 at which 85 colleges, universities and scientific research units displayed a total of 1,292 achievements, of which 70 were registered for transfer, including 15 for which transfer contracts were signed on the spot.

2. All kinds of activities have been initiated to import technology from abroad, establish cooperation with the interior, break down regional and departmental barriers and speed up the transfer of science and technology from scientific research units to production units, from the military to civilians, from coastal areas to the interior and from overseas to China. Economic and technical cooperation projects currently under way, including those in technology transfer and compensation trade, assume myriad forms. According to incomplete data, city-wide, 283 contracts were signed involving Chinese-foreign joint ventures and compensation trade from 1979 through 1984, along with 14,000 contracts for processing and assembling using imported materials and parts. During the same period, 150 production lines and tens of thousand pieces of advanced equipment were imported. Guangzhou has concluded 1,300 economic and technical cooperation contracts and agreements valued at

390 million yuan with 21 provinces, municipalities and autonomous regions. It has imported 31 technical items from and exported 21 technical items to other provinces and municipalities. The municipality has also set up 21 raw material bases.

3. All kinds of technical brainstorming sessions have been held. Over 300 brainstorming and demonstration sessions, large and small, have been held for the 141 key scientific and technical projects given top priority by the municipality in 1984.

4. Scientific and technical stores and various scientific and technical trade organizations have been established. Guangzhou currently has 343 technical service and trade organizations and 39 technical stores. Built by the Guangzhou Science and Technology Development Corporation on 600 square meters of land to the east and north of Yiyuan in Haizhu Square, the 39 stores display, sell and transfer technical achievements, offer technical consulting offices, conduct training and organize technical project negotiations, apart from selling and buying advanced domestic and foreign teaching equipment, medical instruments, computers, home appliances and photographic equipment. They attract droves of customers from inside and outside the province and do a booming business, effectively promoting scientific and technical exchanges and technical trade. Less than 6 months after opening their door, sales already exceeded 9 million yuan and current daily sales reach 50,000 yuan and more.

(3) Unitary markets which sell means of production and means of subsistence under one roof. Such markets mainly comprise fairs and exhibitions for means of production and means of subsistence and "department stores" selling articles of daily use. These multifarious markets where the full gamut of means of production and subsistence can be bought are in effect exhibitions cum trade fairs for new products, new technology and new processes. Competition between new products is in reality competition between different technologies.

Socioeconomic Significance of Technology Market

The appearance of the technology market has done much to regulate the relations between science, technology and the economy, break down the restrictions which have held back scientific and economic developments, quicken the pace of the reform of the scientific and technical system, spur the exploration of new technical terrain and fuel economic prosperity.

1. It has enhanced the social value of knowledge and technology. Owing to the plethora of technical transactions, the value of technology has achieved recognition, intellectuals and mental labor have won respect and "degrees" too have now become valuable. Mastering technology, getting an education and pursuing knowledge therefore have become the order of the day. According to preliminary statistics, 548 high schools and technical schools for employees, with a combined enrollment of 380,000, were established by various industries and trades in the city in 1984 to meet the educational and technical needs of their workers. In addition, there are 160 schools of continuing education and night schools, enrolling over 50,000 students in all. About 330,000 people have attained junior high level after receiving continuing education and

passing an examination, accounting for 61 percent of all workers in the municipality who should go through such training. Among its workers who should receive continuing education at the senior high level, 250,000, or 69 percent, have reached such a standard after passing the necessary examination.

2. It has brought scientific research and production even more closely together and popularized the application of scientific research achievements. According to statistics on 30 specialized research institutes under the municipal government, of the 125 research projects completed in 1984, 87, or 69.6 percent, were popularized and applied the same year, representing an increase of 20 percent over 1978.

3. It has promoted efficiency within scientific research units and boosted their incomes, with a corresponding improvement in their research conditions. Previously it took a technical worker at the provincial Electronics Research Institute an average of 18 years to come up with an achievement. In 1984, of the 15 projects which the institution had won bids to undertake, the largest one was completed within 19 months by just 5 people, and 3 projects were completed before the year was out. Statistics show that the 39 municipal specialized research institutes earned 6.6 million yuan in 1984, up almost 200 percent and 65.8 percent respectively over 1981 and 1983. According to 1984 year-end data, of the 37 development and applications institutes under the municipal government, 21 have put up new scientific research buildings, thus tentatively solving the problem of a lack of intermediate testing sites.

4. It has cleared the channels of technology transfer and promoted extensive technical cooperation and economic linkages. Through market exchange, a large number of new technologies and achievements have obtained outstanding economic and social results. In the wake of the circulation of technical commodities, a network of cooperative relations has gradually taken shape. According to statistics at the end of 1984, the municipality has established ties with 200 colleges, universities, scientific research organizations, academic bodies, manufacturers and companies in more than 20 nations and regions. Domestically it has also entered into cooperation with the colleges, universities, scientific research organizations and enterprises in 21 provinces, municipalities and autonomous regions.

5. It has promoted the rational mobility of intellectuals and scientific and technical personnel. Since its founding in 1983, the provincial Skilled Personnel Circulation Center has carried out its job as an "intermediary" and "go-between" in personnel circulation enthusiastically. By the end of 1984, 4,500 specialized personnel of all kinds have registered with it, of whom 1,300 have tentatively been selected by 400 employing units, including 400 who have completed their transfer formalities. At the 5-day Guangzhou skilled personnel circulation conference in August 1984, 8,700 people asked for a transfer and 3,100 of them received preliminary job offers from employing units, including 200 who completed their transfer procedures soon after the conference.

Some Suggestions For Further Invigorating the Market

Guangzhou has only taken the first step toward developing its technology market. There remain many urgent problems which we must examine and resolve in earnest if we are to ensure effectively its healthy and successful development.

1. Strengthen the macro management and guidance of the technology market. Already Guangzhou's market takes a multitude of forms. Whether they are permanent or temporary, specialized or comprehensive, and whether they are run by a region, a unit, a public organization, a collective or an individual, we must treat them alike, giving all of them encouragement and support. We should gradually establish and perfect the rules and regulations governing the market and draw up as soon as possible regulations for scientific cooperation contracts, legislation on scientific and technical consulting and circulation procedures for scientific and technical personnel, etc., in order to stimulate the development of the market.

2. Step up research into technology market policies. As the technology market is a novelty in China, its birth and growth raise many policy issues which we must examine and explore in theory and practice, eg., the commodity value of technology, prices, the distribution of the benefits of technology transfer and so on. Banking institutions and finance and tax agencies should facilitate the market with preferential treatment.

3. To further invigorate the technology market, we must reform and improve our own work in the development, acceptance and introduction of technical achievements in light of the need to develop the technology market and speed up the commercialization of achievements.

(1) Colleges, universities and scientific research units must gradually outgrow the "planned scientific research model" and adopt a "scientific research as a business model." They must firmly foster the concept of the market, business values and a strong sense of competition, establish and perfect their own business mechanisms and technical service systems step by step, and do their best to produce high-quality and popular, marketable technical commodities for the technology market.

(2) Production enterprises should intensify their consciousness of using new technology. This is of decisive importance to the development of the technology market. Basically the prosperity of the technology market depends on the technical needs of enterprises which, in turn, are closely related to government policies toward the use of new technology and the enterprises' own economic vitality. Hence we must encourage and support enterprises to adopt new technology and develop new products with the right policies. Enterprises, for their part, must devote major efforts to augmenting their ability to absorb and develop technology. To that end, they must rely on science and technology to renew their products continuously and solve a host of problems in industrial production, eg., those relating to quality, the consumption of raw and other materials, productivity and equipment.

(3) We must develop and perfect more technical exchanges, trade, consulting, service, information and notarization institutions of all kinds, put together and train a contingent of scientific and technical personnel and managers and gradually establish the technology market as a trading system.

4. Uphold the open door policy, integrate the domestic technology market with the one overseas and make the absorption, assimilation, innovation and transfer of imported advanced technology an important aspect of the task of developing a technology market with Guangzhou characteristics. We must combine the import of foreign technology and capital with the establishment of economic linkages with the interior and give technical personnel access to knowledge from abroad, in this way making full use of Guangzhou as a city "with a dual orientation, to the world and to the nation, and as a link between the two."

12581
CSO: 4008/2062

LIAONING PLANS INCREASE IN TECHNOLOGY IMPORTS

OW310812 Beijing XINHUA in English 0727 GMT 31 Jan 86

[Text] Shenyang, 31 January (XINHUA)--Northeast China's Liaoning Province plans to spend twice as much hard currency importing technology between 1981 and 1986 than during the previous 5 years.

Liaoning, a major heavy industrial center in China, will spend 3 billion U.S. dollars introducing 3,000 items of technology over the next 5 years, said an official of the provincial Planning Commission here today.

Foreign funds will comprise a third of this amount and will be introduced in such forms as loans, Sino-foreign joint ventures, cooperative businesses, compensation trade and leasing.

Foreign technology and equipment will be used to upgrade 275 major enterprises and develop 450 new products in such areas as metallurgy, electronics, machine-building, chemicals, energy, building materials, textiles and light industry.

Moreover, foreign funds will be used to speed up construction of harbors at Dalian, 1 of the 14 coastal open cities, and other ports. Three new airports will be built in the provincial capital of Shenyang, Dalian and Chaoyang, respectively.

Technology imports are expected to enable 70 percent of the province's machinery to meet the advanced international standards of the late 1970s and early 1980s by 1990, compared with the present 32 percent.

The electronics industry will concentrate on developing microcomputers and microprocessors, while the Anshan Iron and Steel Company, one of China's largest, and other steel makers will import new rolling mills to boost output.

/12232
CSO: 4010/2010

NDSTIC TO EXPERIMENT WITH NEW RESEARCH APPROPRIATION SYSTEM

Beijing BEIJING KEJIBAO in Chinese 8 Jan 86 p 1

[Text] An experience exchange conference on the restructuring of the defense scientific and technical system was recently convened in Beijing by the National Defense Science, Technology, and Industry Commission. Leaders from the various military industrial ministries, various arms of the services and some research institutions and factories which have been carrying out pilot projects attended the conference to talk about their experience and discussed ways to restructure more effectively the defense scientific and technical system.

In line with the CPC Central Committee resolutions on restructuring the economic and scientific systems, and the spirit of relevant government regulations, the reform of the defense scientific and technical system has made new progress in breadth and depth over the past year or so. Particularly effective have been its trial reforms to adopt a paid contracting system. New experience has been gained in this area.

The core of the present effort to reform the defense scientific and technical system is to replace the appropriation system of defense research trial-manufacturing funds with a paid contracting system in order to meet the demands of developing a planned commodity economy and the commercialization of research achievements. Such a change will make it easier to match scientific research trial-manufacturing funds with tasks and ensures that the principle put forward by the Central Military Commission -- "shorten the battlefront, stress our priorities, tackle scientific research aggressively and quicken the pace of modernization" -- is realized. It will also help delineate the boundaries between the economic and technical responsibilities of research and development departments, on the one hand, and departments which apply the results, on the other; mobilize the two kinds of initiative and facilitate the overall planning of scientific research units so that they can devote some of their resources to civilian research and transfer military technology to the civilian sector. Under a paid contracting system, scientific research units will enter into agreements directly with departments which apply their results. Legally their relationship is adversarial. In terms of work, however, they are a partnership devoted to the completion of a joint research project.

12581
CSO: 4008/2061

PRC CONTINUES TO STRENGTHEN BASIC RESEARCH

OW040740 Beijing XINHUA in English 0706 GMT 4 Mar 86

[Text] Beijing, March 4 (XINHUA)--An official from the science and technology leading group under the State Council told XINHUA today that China will continue to strengthen basic research, ensuring technological reserves for the country's economic and scientific development.

Last Thursday, the State Council issued a circular on establishing a national natural science foundation to support basic and applied research.

In line with the country's plan for science and technology development, he said, the science foundation will work out guidelines for applications and give instructions to basic research projects so as to make them comply with the country's long-term development plan.

He said special attention should be paid to those basic research projects with applications for developing China's natural resources.

The establishment of the national natural science foundation is an important measure of the changes in the science funding system, as required in the decision on reforming the scientific research management issued by the Chinese Communist Party Central Committee in March, 1985.

The official said the state allocations will be the main source of funds for the foundation, but contributions from units and individuals at home and abroad will be welcome. Funds for the foundation will be increased faster than the rate of increase of regular state revenues.

The foundation will organize scientists and specialists to appraise applications from across the country and support those projects of vital importance.

All scientific workers in the country will be eligible to apply for grants from the foundation, in accordance with the guidelines and relevant regulations worked out by the foundation, the official said.

The establishment of the foundation will make good use of the present limited spending on scientific research, bring the initiative of scientific workers into full play and raise the academic level of research projects, he added.

/12712
CSO: 4010/2008

HEILONGJIANG DEFENSE INDUSTRY HELPS INVIGORATE LOCAL ECONOMY

Beijing RENMIN RIBAO Overseas Edition in Chinese 29 Jan 86 p 3

[Article by Wu Xiaodong [0702 0879 2639]: "Heilongjiang Defense Industry Produces Civilian Goods"]

[Text] The vigorous drive by the defense industry in Heilongjiang to achieve military-civilian integration has been highly successful. In 1985, over 60 percent of the industry's total profits were derived from civilian products.

With its modern equipment and formidable technological prowess, Heilongjiang's defense industry has gradually shifted from serving national defense exclusively to contributing to key strategic aspects of the national economy and invigorating the local economy. Exploiting its own strengths, it has actively modified its product mix and successively developed over 200 types of civilian products. The civilian output value of military industrial enterprises rose 3.4-fold last year over that in 1980.

In developing civilian goods, the military industry goes out of its way to contribute to the various trades and industries in the national economy. To help energy exploitation and the transportation industry, they make the Yun-12 aircraft, mini cars, coal mine hydraulic supports, oil drilling equipment and graders, among other things; for agriculture, they make small tractors, large shed frames, flour-milling machines and oil presses; for light industry, they make aluminum alloy, bicycles, washing machines, liquid petroleum gas containers, stoves and sports equipment; for construction and other trades, they make tower cranes, bulldozers, construction equipment, dies and aluminum products. Military industrial enterprises insist on quality first; over the past few years they have captured 1 National Gold Quality Prize, 3 Silver Quality Prizes and 29 ministerial or provincial good-quality prizes.

12581
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PROPOSED MEASURES TO MAKE FUZHOU FUJIAN'S SILICON VALLEY

Fuzhou FUJIAN LUNTAN [FUJIAN FORUM] in Chinese No 5, 5 May 85 pp 29-31, 39

[Article by Lin Qiping [2651 0366 14[illegible]6]: "Fujian To Establish Its Own 'Silicon Valley'"]

[Text] The success of Silicon Valley has led to the spread of the silicon valley pattern of development and its imitation all over the world, the emergence of a veritable "silicon valley craze." This new technological revolutionary trend, with electronics as its core, truly deserves our conscientious study.

I

We in Fujian Province must establish our own silicon valley.

1. Establishing a silicon valley will enable us to skip the traditional developmental stages and move to the forefront of China. In nationwide perspective, Fujian is a rather backward province, both industrially and agriculturally. If we want to "move to the forefront of the country" within a short period of time, we have to skip the traditional developmental stages; the only reliable method these days to do so is to employ new advanced technologies in technologically transforming the traditional industries and trades, and, for that purpose, to concentrate on one industry as the pioneering sector and breakthrough point, the development of which would then provide the impetus for technological transformations in all other industries. This industry can only be the electronics industry. The U.S. magazine SCIENTIFIC AMERICAN is entirely justified in calling the electronics industry "the wheel of the 20th century" and "the bridgehead of the new industrial revolution." In its application, electronics is a general technology of the widest scope. All such areas as the rapid development of equipment for the automation of production processes, improvements in management and control in industry, commerce, finance, and in government organs, innovations in medical, pharmaceutical and scientific instruments, as well as modernization of information, broadcasting, and television networks, all rely on electronics. Its development will spur on the rapid development of all other industries and will be an important factor that could possibly allow us to skip the traditional developmental stages and move on to the forefront in China. Development of electronics is particularly suited to the special

characteristics of Fujian Province, which, although rich in natural resources, lacks the raw materials needed for the steel industry and lacks such sources of energy as coal, electric power, and petroleum, while the electronics industry, on the other hand, requires little energy and few materials. The development of the electronics industry requires a region with pioneering quality, which will constitute a core from which influence will radiate in all directions, spurring on developments in other regions. This, then, is what we want to develop as our own silicon valley in Fujian Province.

2. Establishment of a silicon valley will enable Fujian Province to play a special role in opening up China to the outside world. In Fujian Province, the electronics industry had its start in the late 1950's. It has developed rapidly and achieved a new breakthrough particularly since the initiation of the open door policy. As to the value of its production, in 1981 Fujian placed 16th among the nation's electronics industries, jumped to 8th place in 1983, and doubled the value of its production in 1984 compared to 1983, occupying 6th place in the country, electronics ranking third among Fujian's major industries. There are now over 500 types of products, which fairly cover the whole area. We therefore find in Fujian Province a certain foundation for the production and technology of an electronics industry. If we develop our own silicon valley in Fujian Province, it is bound to promote rapid further development of the electronics industry and other newly arising technologies in Fujian, and may quite possibly raise our electronics industry to an even more prominent position in China, so that it will become an important window and base of national significance for the importation and development of new technologies, centering on electronics, effectively play a special role as a provincial share in the opening up to the outside world, and greatly contribute to China's four modernization projects.

3. Establishing a silicon valley has been the strategic measure employed by Third World countries and territories in their efforts to move into the world arena with the development of their economies. The development of the electronics industry in the world, although mainly concentrated in such developed countries as the United States and Japan, is now an area where developing countries are doing all they can to catch up. Those that started early in this race were China's province of Taiwan, South Korea, Singapore, and Brazil. They all proceeded, one after the other, by establishing their own silicon valleys according to the pattern of the original Silicon Valley. In 1979 the Singapore government set out to establish a science and technology park at Kentegang, near Singapore University, as an entity that would facilitate the importation of new technologies. Taiwan also began, toward the end of 1980, to establish a science and technology park at Xinzhu for the importation of most advanced foreign technologies and to develop new technology-intensive industries. Up to now over 60 percent of the more than 30 enterprises approved for investment in the park were electronics and information processing enterprises. If the province of Fujian, an advance outpost of this Third World country of China, wants to attain worldwide significance in its efforts to open up to the outside world, it must also provide a base for an electronics industry and for high technology production, which means that it must also establish its own silicon valley.

II

Where should Fujian's silicon valley be located? In my opinion, it should be established at Fuzhou, a place with many favorable conditions for rapid development.

1. Fuzhou has a definite foundation as an electronics industry base. Currently, there are 108 enterprises of the electronics industry system throughout the province, of which about one-third are concentrated in Fuzhou. The electronics industry employs 22,157 staff and workers, and the Fuzhou Electronics Industry Bureau alone employs 6,716 of them, which is also about one-third. According to 1982 statistics, the output value of Fuzhou's electronics industry accounts for 43.13 percent of that of the whole province, placing it first in Fujian. Fuzhou's electronics industry is of decisive economic importance for the province and for the entire industrial system of Fuzhou itself. In 1985 its output value will place it among the top three industries of the municipality. In 1986 the profits that it will turn over to the treasury will be equal to the total amount turned over in 1983 by all municipality-run industrial enterprises. By 1990 its output value will be equal to the total output value of all municipality-run industries in 1983, reaching 1.2 billion yuan, which will be more than twice the total output value of 470 million yuan achieved by the entire province's electronics industries in 1983.

2. Fuzhou has a very strong scientific and technological work force. The electronics industry is "an industry based on scientific research," a "knowledge-intensive industry," or "technology-intensive industry." Its development is closely bound up with the foundation available in scientific research conditions and in scientific and technological strength. The province has five research institutes specializing in electronics, one each in the field of electronics, optics, computers, semiconductors, and communications, and one electronic products control and inspection office, all located in Fuzhou. The Fuzhou Electronics Industry Bureau employs 500 of the 1,866 engineering and technological personnel, and if the provincial electronics enterprises located in Fuzhou were included, the figure would be more than half. Fuzhou also has universities and colleges, such as Fuzhou University, Fuzhou Normal University, etc., which have specialized instructional and research establishments for electronics, optics, semiconductors, computers, and other high technology, and which have indeed already achieved outstanding successes in their scientific research, such as the HCP system developed by Fuzhou University, which is a first in advanced software tool manufacture in China. Fuzhou has also 36 scientific research organs, 450 high-ranking specialized research fellows, and 18,800 specialists in the natural sciences--altogether a large science and technology force, constituting a definite capacity for scientific and technological development and for the comprehensive handling of key projects, well capable of rapidly applying scientific and technological research results and absorbing and digesting advanced science and technology imports from abroad, and also capable of pursuing inventions and innovations.

3. Fuzhou has several excellent key electronic enterprises, some of them renowned at home and abroad, such as the Furi Company, which is the first

Chinese-Japanese joint venture enterprise in Fujian. In quality its television sets equal any similar type manufactured by Hitachi, and the sets have indeed been able to penetrate domestic and foreign markets. The productivity of the entire work force ranks at the top in this line of industry throughout all of China. The Fuzhou Computer Factory is the largest factory in the whole province; it is manufacturing microcomputers and calculators. The calculators are a staple product of Fujian's electronics industry, accounting for one-quarter of the total national production, and considered the best in the country. There is also the Fuzhou Radio Factory which manufactures the "191-model digital multimeters," a production that fills a gap in China's production of testing equipment. These excellent key enterprises will promote developments in a large number of cooperating factories and component plants, and will exercise leadership in the development of Fuzhou's electronics industry and other high-technology industries.

4. Fuzhou has a transport and communications network that extends in all directions. Good access to information is an important condition for the development of electronics and high technology industries. Fuzhou has well-developed communications and an even more advanced telecommunications system. The city has imported from Japan a complete set of equipment for a computerized time-division exchange system for a 10,000-channel city telephone system and for a 500-channel long-distance telephone system, enabling automatic direct dialing to places within China and abroad, and establishing long-distance telephone connections with various large cities in 41 countries, thus facilitating quick transmission of information.

All the above-mentioned favorable conditions provide Fuzhou with a sound initial basis for the development of electronics and high technology industries and make Fuzhou a favorable place for the establishment of a silicon valley. However, in order to achieve the development of an electronics and high tech industry of domestic and foreign significance, which will also be capable of spurring on the electronic industry of the entire province, and which will also turn Fuzhou into a pioneering district that will stimulate an upswing in all other industries throughout the province, it will of course be necessary to employ many further measures.

III

The following measures should be adopted to establish a silicon valley at Fuzhou:

1. It is necessary to determine a developmental plan for an intermediary period. In view of the characteristics of the Fuzhou electronics industry--its many small factories and large number of component factories--it is necessary, when determining the plan for the intermediary period, on the one hand, to base oneself on the presently available technology imports and technical transformations so far effected in the electronic enterprises, and to proceed in three stages. First stage: stress on the assembly of components, importation of advanced production lines for components, thereby laying a solid foundation. Second stage: emphasis on the readjustment of all machinery, importation of key equipment, key parts and random parts, the

production of complete electronic equipment of an advanced nature. Third stage: emphasis on prime items, best hot-selling goods, such as color TVs, electric refrigerators, video recorders for industry, microcomputers, etc., to bring about vigorous development and an economic upswing. On the other hand it is also necessary to pay serious attention to the opening up of new territory, to be conceived as: (1) Preparations for the establishment of an electronics industry university, mainly for the purpose of training postgraduate students and for the pursuit of scientific research. (2) Establishing a research institute for the development of software, to assume the tasks of scientific research development, development of industry, technological and economic research, technological projecting for all the various trades and industries, research in computer applications, and the gradual building up of a software force, turning the Fuzhou region into a software development center.

2. Pursuing a three-pronged course, accumulating capital through a variety of channels. The electronics industry requires large investments; hence it is called an "investment-intensive industry." Operation of a large-scale factory requires the expenditure of hundreds of millions of yuan. Following World War II, the major capitalist countries, especially the United States, Japan, Great Britain, and the FRG, invested at a high rate--about 3 to 5 percent of their GNP--in their electronics industries. For the last 10-odd years, the rate at which investments in the U.S. electronics industry increased exceeded the rate of increase in investments of the entire industrial sector. Turning Fuzhou into the silicon valley of Fujian Province within a short period of time requires large capital funds. However, raising large investment funds within the province and within the city would currently be very difficult; such funds must be sought through a variety of channels and should be pursued in a three-pronged way: On the one hand, capital may be absorbed from sources inside and outside the province, including capital of the state, of the collectives, and from individuals. On the other hand, joint operations with foreign enterprises should be initiated. Among all cases of importations by the Fuzhou Electronics Industry Administration during 1984, 11 cases were joint venture operations. We have by now accumulated a certain amount of experience in this respect. In the future we shall pay attention not only to the digestion, absorption, and conversion to domestic production of the imported items, but also to importing certain items that are of high technological level, that are difficult to manufacture, and that are highly sophisticated. And in yet another respect, when foreign enterprises invest their own funds to operate electronics industries in Fuzhou, the key target for our efforts to obtain such investment funds should be enterprises set up overseas by Chinese scientists of some achievement and most of the famous United States and Japanese high tech companies.

3. Importance must be attached to the transfer of technologies. An important experience gained from the success of Silicon Valley is the implementation of a policy of effecting technology transfers by a close linkage between universities and enterprises. In this manner the technology is transferred from the classrooms of the universities and from research offices to the various enterprises, in a kind of fast conveyor belt of knowledge for transports from institutions of higher learning and scientific research organs to the industrial enterprises, so that the technology can be speedily and

effectively used in actual production. In our efforts to establish Fuzhou as the silicon valley of Fujian Province we must fully assert the role of the universities and relevant research organs in Fuzhou City. For this purpose: (1) The Fuzhou University, being an industrial university with a very strong technical curriculum, must strengthen its research in latest technologies and must, furthermore, speedily transfer any achievements of its research to the enterprises. (2) Universities or research organs with suitably favorable conditions may, in an accurate assessment of the market situation and staying within the means presently available to them, start up by themselves enterprises appropriate to the needs of the times and develop electronic products required in the international market. (3) Universities or research organs may set up joint ventures with enterprises, having the enterprises invest capital and the university invest the intelligence of its personnel for an effective integration of capital and intelligence.

4. Importance must be attached to intelligence work and access to information. An enterprise that lacks advanced technology is of course in jeopardy, but more dangerous still is an ineffective state of its intelligence gathering and of its access to information. Our efforts to establish Fuzhou as the silicon valley of Fujian Province makes it absolutely necessary to pay strict attention to intelligence gathering and access to information. It is necessary to: (1) Establish a modern intelligence and information center, gather and study the production and marketing conditions of the electronics industries in the domestic and foreign markets, and their technological data, research achievements, etc. (2) Developmental strategy and import activities of the electronics industry must be based upon intelligence and information, to prevent irrational operations. (3) Based on market information and on scientific and technological information, efforts must be directed toward the improvement and updating of electronic products; we must strengthen the manufacture of new products in complete sets, change the composition of our products, and develop components and adjust machinery to form complete sets.

5. We must go all out in the successful utilization of intelligence, because Fuzhou's electronics industry now consists to a large proportion only in the assembly of imported parts, has a weak foundation, poor flexibility to meet changes in the situation, and is, furthermore, still rather backward in its production technology. Under these conditions, speedy development can only be achieved by going all to successfully utilize intelligence. This may be conceived as the need to proceed in the following directions: (1) To bring in, in a planned manner, highly qualified foreign technical personnel, placing special emphasis on bringing in Chinese of real ability and learning and scientists of Chinese descent. (2) To bring in from outside of Fujian Province a number of technical talents of the electronics industry and to import most advanced technologies. (3) To send a number of technical personnel, known to be highly devoted to their work, for advanced training to countries with highly developed electronics industries, such as the United States, Japan, and the FRG. (4) To strengthen supplementary general education and technical training of staff and workers, especially of young workers; organize staff and worker's participation in studies at electronics universities, vocational universities, and correspondence universities; organize advanced studies and training of technical personnel; raise the

overall technological quality of all staff and workers and of the scientific and technological work force.

6. Effectively implement a division of labor between the different factories. The electronics industry faces the fiercest competition in the international markets. Since we intend to establish Fuzhou as the silicon valley of Fujian Province, its electronic products must be targeted for the international markets; our opponents in the competition are, therefore, the advanced electronics industries of the various countries of the world. That makes it necessary to institute a division of labor within the province, and especially within our region; there must be no mutual competition for goods that are easy to sell. In the original Silicon Valley many different companies vie with one another to achieve one identical objective, while only one will in the end come out victorious. The others will only have paid a huge price and be left to bemoan their fate. This is a mortal defect that capitalism cannot overcome. Ours is a socialist state; we can effect macroeconomic regulation, allot each factory its share of work, and concentrate our strength on efforts to give a good account of ourselves in international markets.

9808
CSO: 4006/930

'SPARK PLAN' IMPLEMENTED IN XINJIANG

Beijing RENMIN RIBAO Overseas Edition in Chinese 26 Dec 85 p 3

[Article by Bei Feng [0554 7364]: "Xinjiang To Launch 'Spark Plan' Projects"]

[Text] It has been learned from relevant departments that the Xinjiang Uygur Autonomous Region has begun to implement the state's "Spark Plan" and is selecting contractors for three projects assigned by the central government -- the development of the Hamie melon family of products, the integrated development and utilization of bluish dogbane and the artificial propagation of licorice root. In line with the spirit of the plan, and to complement it, the autonomous region is discussing tentatively the drawing up of a group of scientific and technical development projects which require little capital, pay off quickly and are suited to the characteristics of local enterprises.

Formulated by the State Science and Technology Commission and approved by the State Council, the "Spark Plan" is aimed at tackling the low technological standard and poor competitiveness of rural, township, small and medium-sized enterprises, reducing the threat to their market posed by the invigoration of large enterprises and laying the foundation for local economic development. The implementation of the "Spark Plan" will funnel science and technology toward the vast countryside and significantly quicken the pace of the development of rural and township enterprises.

Under the "Spark Plan," the central government, provinces, autonomous regions, prefectures and counties regularly propose a number of projects which meet domestic and international demand and have a short turnover period, require little capital and produce quick economic results, the idea being to make them part of a systematic network of projects. Whenever a batch of achievements is ready for popularization, they will be popularized so that science and technology are disseminated as soon as possible. At the same time, the government will support a large number of demonstration enterprises and integrated bodies to increase the ability to absorb and disseminate technology and strengthen the organizational base of the technology market. A meeting has recently been held by the relevant agencies in Xinjiang to make plans for resource surveys in various localities and come up with feasible development projects for inclusion in the overall development plan of the region. In addition, the three projects assigned by the state have been included in the "Spark Plan" after verification by Xinjiang's science and technology agency.

A bidding system will be adopted for the region's "Spark Plan." The required funds will come from the state, localities and enterprises. If necessary, foreign software may be imported, but in general no hardware will be purchased from abroad.

12581
CSO: 4008/2061

NATIONAL DEVELOPMENTS

BRIEFS

CONTINUING EDUCATION IN FUJIAN--In light of the urgent needs of scientific and technical personnel, the provincial Science and Technology College for Advanced Studies conducted a total of 90 courses in the "Sixth 5-year Plan" period to "make good the gaps in their education and training and bring them up to date with the latest knowledge." The courses, which took a variety of forms, provided systemic continuing education for 3,929 senior-, middle- and junior-level scientific, technical and managerial personnel in the province. So far 2,393 professionals from all trades and industries have received single-subject graduation certificates. The courses have resulted in an infusion of scientific, technical and managerial experts at varying levels of expertise and in various specialties into such areas as teaching, scientific research, design and production. After graduating from the courses, many students have achieved outstanding economic and social results in their work in scientific and technical translation, foreign activities, scientific research and production management. [Text] [Fuzhou FUJIAN RIBAO in Chinese 24 Jan 86 p 2] 12581

PRIZES AWARDED--Beijing, 6 March (XINHUA)--The Chinese Academy of Sciences announced today the 20 winners of its biannual Zhu Kezhen prize for outstanding contributions in scientific field work. The prize, inaugurated in May 1983, is named after Zhu Kezhen, former vice-president of the academy and a pioneer in surveying China's natural resources. The first group of 38 scientists was given the prize in 1984. Most of this year's prize winners have participated in scientific surveys and field experiments for over three decades in glaciology, geology, geography, meterology, pedology, botanical ecology, insectology and ichthyology. Among the winners is Dai Liren, senior engineer at the institute of oceanography in Qingdao. Last year, at the age of 74, he joined a survey of the western Pacific region aboard a Chinese scientific research ship. Another is Shi Yafeng, honorary director of the Lanzhou Institute of Glaciology and Geocryology. He has conducted glacial surveys in western China over the past 30 years and has published more than 100 academic papers and reports on glaciers and landforms. [Text] [Beijing XINHUA in English 1533 GMT 6 Mar 86] /12640

CSO: 4010/2009

PHYSICAL SCIENCES

RESEARCH ON EMP NEAR TO NUCLEAR EXPLOSIONS AT LOW ALTITUDES

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 10 No 4, Jul 82 pp 54-62

[Article by Lai Zuwu [6351 4371 2976], Wu Bosheng [0702 3134 3932], and Li Guanglun [0500 0342 0243]; paper received March 1981, finalized August 1981]

[Text] English Abstract: The EMP is one of the most important phenomena of nuclear explosions. The main features of EMP in the vicinity of airbursts have been researched. At the instant of an explosion, there exist both radial electric field and radiated electromagnetic field even in the source region. But the radial electric field is dominant and the radiated field is comparatively weak. This region can also be called the saturated electromagnetic field region, because the electric field reaches a certain maximum value which is not a function of the weapon yields but merely depends on the parameters of the environment. Beyond the region, the radial electric field diminishes to zero and then the radiated electromagnetic field becomes dominant. The conditions for creating the saturated field and the various EMP waveforms are discussed in this paper. On the basis of Gilinsky's assumption and considering the actual gamma time behavior instead of the "jump" wave, the expanding dipole mode may be suggested and can give satisfactory explanations of the detailed wave shapes in the early parts of EMP.

I. Introduction

Many public documents concerning research on nuclear electromagnetic pulse [EMP] have been published,[1-4] and a number of physical models of the mechanisms which produce it have been put forth, the most important of which are the Compton (or photoelectron) mechanism, the geomagnetic field deflection mechanism, and the field displacement mechanism. Since these models are all derived on the basis of definite simplified hypothetical conditions, they are frequently inadequate to explain the much more complex phenomena in reality.

This paper is based primarily on tests. It summarizes and discusses the models of EMP production in the vicinity (that is, within 10 km of the blast center) of low altitude and surface nuclear explosions and their main characteristics, with attention to establishing a clear physical image and describing the regular phenomena (without reference to the results of a certain specific experiment).

II. Physical Models in the Vicinity of Nuclear EMP

Although there are many ways of describing the physical mechanism which produces nuclear EMP, for low altitude and surface nuclear explosions, Gilinsky's electric dipole model[2] is the closest to actuality and belongs to Compton's electric current mechanism. The results provided by this model assume that the gamma-source takes the form N_0be^{-bt}, i.e., it recognizes that the ascending leading edge of the gamma-source is a step function, and that there is a big difference between this and the approximation of the ascending leading edge of the gamma-source of an actual nuclear explosion as an exponential function, correspondingly, the early part of the EMP is overlooked. At the same time, there are certain demands on the distance between the observation point and the blast center: the distance must be much greater than the length of the moment of dipole to be able to satisfy the electric dipole hypothesis. Clearly, a nuclear explosion source region observation point does not satisfy this demand. Proceeding from the experimental results of EMP in the vicinity of nuclear explosions, we improved this model and proposed a central expansion electric dipole model which can better explain the basic phenomena of the nuclear EMP in the vicinity.

1. Physical Image of the Central Expansion Electric Dipole Model

The EMP produced by a nuclear explosion is primarily caused by instantaneous gamma rays. The average energy is about 1 Mev gamma ray, and the primary form of interaction with the surrounding matter is Compton scattering. Scattering produces Compton recoil electrons, which carry the bulk of the gamma-photon energy, primarily flying along the radius forming Compton current J. In the vicinity of the blast center, the charge separation between the Compton electrons and the parent nucleus creates a powerful electron field E, whose direction is primarily radial and is called the radial field. Along their path, the Compton electrons ionize the air producing a large quantity of secondary electrons which also are absorbed by oxygen atoms at a rate of about 10^8/s to form negative ions. At the same time, positive ions combine with electrons and negative ions at a slower rate to become electron neutral and make the electrical field disappear. Because the number of these charged electrons produced by gamma rays at the moment of the nuclear explosion are far greater in number than the number that disappear, a highly ionized region appears in the air in the vicinity of the blast center. As the distance from the blast center increases, the degree of ionization gradually decreases. Because of the existence of degree of ionization, the air around the blast center has conductivity σ. With the action of the electrical field, a conduction current σE appears. If there is no symmetry in the blast conditions, this system will radiate electromagnetic waves outward. As an approximation, this system can be treated as an electric dipole radiator. Because there is polarity opposition between the two currents in the system--the Compton current and the conduction current--the two provoke an interactive compensation.

The growth and decline between them is the basic cause of the complex phenomena of nuclear explosion EMP.

At a certain moment of a nuclear explosion, the electrical field space in the vicinity of the blast can be divided into three areas. The blast center is a plasma region in which the degree of ionization is very high; a region outside the plasma region is the saturation region, where the degree of ionization causes a dynamic balance between the conduction current and Compton current, and after the electrical field value rises to a maximum value, it no longer increases; outside the saturation region is a transitional region which increases with the distance from the blast, where the maximal value of the radial field rapidly drops from the saturation value to zero, but the radiating field value decays very slowly with the distance. These two fields gradually overlap from radial field to radiating field. Outside the transition field, the radial field is close to zero, and it only manifests a radiating field.

In the blast process, from the perspective of time, the above three areas have a process of formation and expansion outward. The process relies on the temporal relationship of the instantaneous gamma-source. According to the temporal relationship of the gamma-source assumed by Gilinsky, implying that at the initial moment of the nuclear explosion, a fixed radius plasma region and a fixed radius saturation region suddenly appear. However, in an actual nuclear explosion the gamma-flux rising approximation is an exponential function. The corresponding physical process should be: the ions near the blast center gradually rise, the central plasma region and saturation region gradually expand outward and reach a maximum radius. The corresponding moment of electric dipole distance also gradually increases to its maximum extent. Under such conditions, near some observation points the moment of gamma-flux peak does not satisfy the hypothesized electric dipole conditions but the initial period of the blast does. In the initial period of the blast, the blast center is only a very small area, its degree of ionization is very high, and the blast center can be viewed as only having a small radiating body, and only as the time increases does it gradually grow. Thus, these observation points in the early period of the blast may be taken care of by using electric dipole radiation. As the time increases, the gamma-flux rapidly grows, the moment of electric dipole also grows rapidly, and the electric dipole approximation becomes increasingly untenable, but at this time, at these observation points the radial field has already become an important contribution.

The above physical image shows that the nuclear explosion system we are discussing is an active field. Mathematically, to avoid the appearance of a singular point in the source point, it is necessary to deduct the source point and treat it as a boundary condition. We assume that in the source point there is a fully conducting sphere, and as it changes with the temporal relationship of the gamma-source, from its initially arranged radius it expands to a plasma area of several hundred meters. The boundary expansion rate is computed from the actual gamma time spectrum. Thus, observation points which are nearby in the early period of the blast satisfy the electric dipole hypothesis, and electric dipole radiation can be used to compute its radiation field value. At the same time, there is also a rapidly growing radial field value, thus the nuclear explosion EMP of these points should be treated by overlapping the radiation field and the radial field.

2. Describing the Nuclear EMP Equations

The currents that exist in the above described system are the Compton current J and the conduction current σE. The Maxwell equation group contains differential forms for the two equations of temporal change:

$$\nabla \times E = -\frac{1}{C}\frac{\partial B}{\partial t} \tag{1}$$

$$\nabla \times B = \frac{1}{c}\frac{\partial E}{\partial t} + \frac{4\pi}{c}(J + \sigma E) \tag{2}$$

in which c is the speed of light. If the blast is axially symmetric, on the spherical coordinate system, E_φ, B_θ, and B_r are zero, and there are only components F_r, E_θ, and B_φ. According to the electric dipole hypothesis, Compton current, conduction current, and the radial field can be written as a superposition of the symmetrical and the assymmetrical parts:

$$J_r(r,\theta,t) = J_0(r,t) + \xi J_0(r,t)\cos\theta \tag{3}$$

$$\sigma_r(r,\theta,t) = \sigma_0(r,t) + \xi\sigma_0(r,t)\cos\theta \tag{4}$$

$$E_r(r,\theta,t) = E_0(r,t) + E_1(r,t)\cos\theta \tag{5}$$

$$E_\theta(r,\theta,t) = E_2(r,t)\sin\theta \tag{6}$$

$$B_\varphi(r,\theta,t) = B(r,t)\sin\theta \tag{7}$$

in which ξ is a nonsymmetrical factor, but is a small quantity. E_0 and E_1 are the symmetrical part and the nonsymmetrical part of the radial field, respectively. E_2 is the radiation electrical field, and B is the radiation magnetic field. Substituting Equations (3)-(7) in Equations (1) and (2), and overlooking the small second order quantities, we get:

$$\frac{1}{c}\frac{\partial}{\partial t}E_0 = -\frac{4\pi}{c}(J_0 + \sigma_0 E_0) \tag{8}$$

$$\frac{1}{c}\frac{\partial}{\partial t}E_1 = \frac{2}{r}B - \frac{4\pi}{c}[\sigma_0 E_1 + \xi(J_0 + \sigma_0 E_0] \tag{9}$$

$$\frac{1}{c}\frac{\partial}{\partial t}E_2 = -\frac{1}{r}\frac{\partial}{\partial r}(rB) - \frac{4\pi}{c}\sigma_0 E_2 \tag{10}$$

$$\frac{1}{c}\frac{\partial}{\partial t}B = -\frac{1}{r}\frac{\partial}{\partial r}(rE_2) - \frac{1}{r}E_1 \tag{11}$$

Equations (8)-(11) is the equation group which describes the nuclear explosion EMP. Equation (8) is an ordinary differential equation, and when giving the specific expression of Compton current J_0 and air conductivity σ_0, the analytic solution of radial field E_0 can be obtained. Equations (9)-(11) constitute a group of quasilinear partial differential equations, and to find the unknowns E_1, E_2, and B, it is necessary to carry out numerical computations. The temporal relationship of the Compton current and the gamma-source can be approximated thus:

$$I_e(r,t) = -\phi(r,t)\frac{eL}{\lambda} \tag{12}$$

in which, $\phi(r,t)$ is the gamma-flux at point r, e is the electron charge constant, λ is the average free path of the gamma-photons, and L is the average range of the Compton electrons. The air conductivity σ_0 is determined by the charged electron density and their mobility:

$$\sigma_0(r,t) = e(\mu_e n_e + \mu_+ n_+ + \mu_- n_-) \tag{13}$$

in which μ_ε, μ_+, and μ_- are the mobility of the electrons, the positive ions and the negative ions, respectively, and they should be an electrical field function. Here the approximation is taken as a constant. n_ε, n_+, and n_- are the density of the electrons, the positive ions, and the negative ions, respectively, and they are solved by the air chemistry differential equations

$$\frac{dn_e}{dt} = S(r,t) - \alpha n_e - \alpha_e n_e n_+ \tag{14}$$

$$\frac{dn_+}{dt} = S(r,t) - \alpha_e n_e n_+ - \alpha_i n_+ n_- \tag{15}$$

$$\frac{dn_-}{dt} \alpha n_e - \alpha_i n_+ n_- \tag{16}$$

In the equations, α is the coefficient of oxygen atom electron absorption, α_ε is the combined coefficient of electrons and positive ions, α_i is the combined coefficient of positive ions and negative ions. S(r,t) is the secondary source term which can be expressed:

$$S(r,t) = \phi(r,t)\frac{\nu}{\lambda} \tag{17}$$

in which ν is a number of secondary electrons produced by Compton electrons. In actual numerical computations, the temporal relationship of the gamma-source should use the actual gamma-time spectrum. First of all, the charged electron density is solved by the constant differential equations (14)-(16) to determine the boundary of the central plasma sphere and obtain the value of the air conductivity and Compton current, and then solve for the value of the radial field E_0 using Equation (8), and finally compute from Equations (9)-(11) E_1, E_2, and B and superimpose radial field E_0 and radiating electrical field E_2.

3. Radial Field

In order to get a simple image in discussion, some simplification can be carried out. We take into account the flight time of gamma-photons, and use the delay time T = t-r/c. And we let the gamma-source temporal relationship be:

$$\phi(r,T)=\begin{cases}\phi_0(r)\exp(aT) & 0<T\leqslant T_1\\ \phi_0(r)\exp(aT_1-bT) & T>T_1\end{cases} \tag{18}$$

In the equations, $\phi_0(r)$ expresses the gamma-flux at r of T=0 moment, T_1 is the moment gamma-flux reaches peak value. Substituting Equations (18) and (12) in Equation (8), and taking into account that the initial segment conduction current is much smaller than the Compton current, i.e., $J_0 >> \sigma_0 E_0$, we have:

$$E_0(r,T)=4\pi\frac{eL}{\lambda a}\phi_0(r)[e^{aT}-1]$$

or

$$E_0(r,T)-E_0(r,0)=4\pi\frac{eL}{\lambda}\Phi(r,T) \tag{19}$$

Taking into account $E_0(r,0) \approx 0$, therefore we have:

$$E_0(r,T)=4\pi\frac{eL}{\lambda}\Phi(r,T) \tag{20}$$

In which $\Phi(r,T)$ is the gamma-integral flux or r location. From Equation (20) it can be seen that the growth of the initial segment of radial field is in direct proportion to the gamma-integral flux. When the electrical field enlarges and the conduction current increases with it to the point that it cannot be overlooked, E_0 departs from Equation (20), the growth rate of the electrical field gradually diminishes, and ultimately achieves the saturation value E_{0_s}. This segment electrical field has the following form:

$$E_0(r,T)=E_{0s}[1-\exp(-4\pi\sigma_0 T)] \tag{21}$$

Since σ_0 is a function of the distance r, with regard to the same moment, σ_0 diminishes as the distance increases. From the relationship of E_0 and σ_0 displayed in Equation (21) it can be seen that the closer the air is to the blast center, the earlier it achieves the saturation value. When the electrical field achieves saturation, i.e., $dE_0/dt = 0$, we can obtain the following from Equation (8):

$$E_{0s}=-\frac{J_0}{\sigma_0}=\frac{eL}{\lambda\sigma_0}\phi(r,T) \tag{22}$$

Since the mobility of the electrons is much higher than the mobility of the ions, the initial period of the explosion can approximate air conductivity only with the contribution of electrons, the constant differential equation group (14)-(16) is simplified to one differential equation and directly computed:

$$\sigma_0\approx\frac{e\nu\mu}{\lambda(a+\alpha)}\Phi(r,T) \tag{23}$$

substituting in Equation (22), we get:

$$E_{0s}=L(a+\alpha)/\nu\mu \tag{24}$$

in which a is determined by the growth coefficient of the gamma-source, and the others are all parameters of the blast center environment. Equation (24) explains that the radial field saturation value is primarily derived from the blast center environmental parameters and is unrelated to the explosion equivalent. For low altitude nuclear explosions, the saturation value is $10^4 - 10^5$V/m.

Drawing the relationship between the expressions of Equation (18) and Equations (21) together, as illustrated in Figure 1, one can see in general the temporal relationship of the radial field and the gamma-flux. The intensity of the initial period electron field rises in direct proportion to the gamma-flux, but then deviates gradually towards the saturation value. The time corresponding to the field intensity reaching the saturation value is E_{0s}, and at time T_s the gamma-flux is only ϕ_s. And the time corresponding to the gamma-flux peak is T_1.

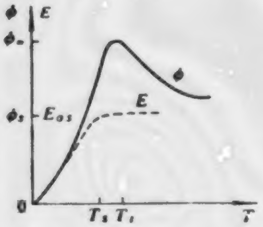

Figure 1. Curve of Temporal Changes of Radial Field and Source Field

Carrying out numerical computations based on the assumed gamma-spectrum under specified conditions, the curves at 150m of variations with time of Compton current J_0, conduction current $\sigma_0 E_0$, and radial field E_0 are as illustrated in Figure 2. It shows that in the initial stage, the growth of Compton current is far greater than the growth of conduction current, and at this time the radial velocity rises. Subsequently, the distance between the growth of the two currents becomes smaller. Beginning at 70 ns, the growth rate of the two almost tends to be uniform and at this time the radial field achieves the saturation value and then fluctuates slightly. The change in Compton current is in direct proportion to the changes in gamma rays. This indicates that change in the radial field is determined by the growth rate of Compton current and conduction current. The time that it reaches saturation value, is not the time that the gamma-source reaches peak value, but is the time Compton current and conduction current growth rates reach a balance.

Figure 3 provides curves of changes in the radial field at different distances. It can be seen that as the distance increases, the ascending leading edge of the radial field is slower and slower, the maximum value is smaller and smaller and the fluctuations in saturation value also gradually become smaller.

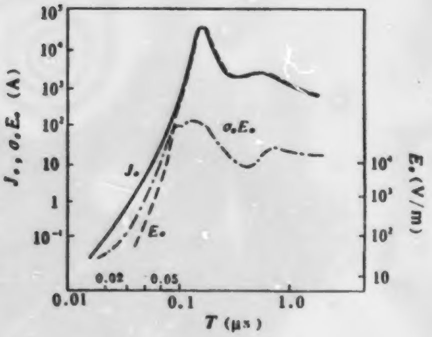

Figure 2. Change of J_0, σ_0, and E_0 at 150m With Time

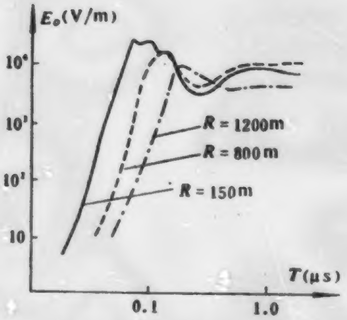

Figure 3. Radial Field Curves at Different Distances

The saturation phenomenon of electric fields is one of the characteristics of source region EMP, and the size of the saturation area can be expressed by the saturation radius R_m. Within the saturation area, the maximum field intensity formed by Compton current J_0 must be much larger than the saturation field value E_{0s}, and can be obtained from Equation (20):

$$4\pi\frac{eL\Phi(R_m,T_1)}{\lambda}\geqslant E_{0s} \tag{25}$$

i.e.,

$$\frac{\exp(-R_m/\lambda)}{R_m^2}N\frac{eL}{\lambda}\geqslant E_{0s} \tag{26}$$

or

$$R_m^2\exp(R_m/\lambda)\leqslant eLN/\lambda E_{0s} \tag{27}$$

in which $N = \Phi(0,T_1)$ is the sum of the gamma-photons released from the start of the nuclear explosion to the peak time. From Equation (27) one can see that R_m increases slightly as N becomes larger, but is not extremely sensitive. For a nuclear explosion equivalent to 10 kilotons of TNT, the R_m is about 1 km, and for a megaton nuclear explosion, the R_m is 2-3 km.

4. Radiating Field

In addition to a radial field, in the source area there is also a radiating field. The waveforms (early part) computed at 300m for the central expansion electric dipole model adopted are illustrated in Figure 4. It can be seen that the initial part radiating field absolute value is far greater than the radial field value, thus the overlapping fields are primarily the contribution of radiating, and in the waveform manifest negativity. Subsequently, the radial field velocity rises, exceeds the radiating field value, and quickly reaches the saturation value.

If we consider the situation when the gamma-source is slowly increasing, then the initial section of the radiating field waveform will have an oscillating nature, as illustrated in Figure 5.

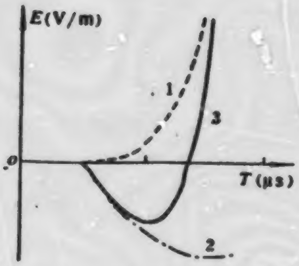

Figure 4. 1-Radial Field,
2-Radiating Field,
3-Source Region Overlapping Fields

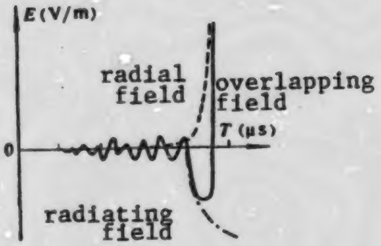

Figure 5. Computation Results of Early Source Region Signals When Gamma-Source Changes Slowly

The slightly later waveform is similar to the waveform illustrated in Figure 4. The field intensity of the oscillating part is between several mV/M and several hundred mV/m.

III. Primary Characteristics of Nuclear Vicinity EMP

On the basis of a discussion of the physical characteristics of EMP in the vicinity of a nuclear explosion, this section summarizes the test results and discusses the primary characteristics of plasma region, saturation field region, transitional region and radiating region with regard to EMP.

1. Blast Center Plasma Region

On-site measurements show that even close to the blast center a very strong electric field can be measured. This means that although the air near the blast center is under the irradiation of high intensity gamma rays, it is not completely ionized. Thus, in theoretical computations, treating the blast center approximately as an ideal conduction sphere is only a crude approximation.

2. Saturation Field Region

(1) Characteristics of Saturation Field Region Waveforms: The waveforms of the measurement source region saturation field of atom bomb explosions and hydrogen bomb explosions are as illustrated in Figure 6, in which E_{0s} represents the saturation field value. No matter whether it is an atom bomb explosion or a hydrogen bomb explosion, the saturation field is a forward pulse, the waveform exhibits a "flat top" and the field intensity is greater than 10^4V/m, unrelated to the explosion equivalent. The duration of the pulse "flat top" may reach more than 10μs. The ascending leading edge may be analogous to the gamma-source, but there are differences with the distance of the measurement point from the blast center. The waveforms illustrated in Figure 3 are equivalent to the initial part of Figure 6(a), the two are similar.

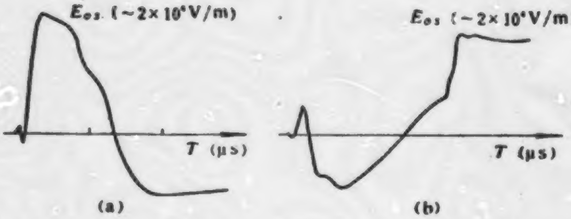

Figure 6. Diagram of Source Region EMP Measured Waveforms
(a) Atom Bomb explosion (b) Hydrogen Bomb Explosion

(2) Necessary Conditions for Forming a Saturation Field: A saturation field is an EMP phenomenon which appears in the special conditions of a nuclear explosion and it is subject to the limitations of time and space. According to Equation (2), when gamma-flux reaches the peak value Φ_m, the electric field formed by J_0 is written:

$$E_0(r,T_1)=eL\phi_m/\lambda a\varepsilon_0 \tag{28}$$

Here, we use the practical units system, $\varepsilon_0=\frac{1}{36\pi}\times 10^{-9}(F/s)$, and if we take λ = 150m, L = 1.5m, a = 10^8/s, and take into account that Equation (28) must satisfy the condition $E(r,T_1)>>E_{0s}$, then

$$eL\phi_m/\lambda a\varepsilon_0 \gg E_{0s} \tag{29}$$

and if we take $E_{0s} = 3.2 \times 10^4$V/m, then

$$\phi_m \gg 1.7\times 10^{22}(1/m^2\cdot s) \tag{30}$$

The above equation is the requirement of gamma-flux for forming a saturation field. Actual measurement results show that only when the gamma-flux reaches such a level will the radial field there be at saturation value. In addition to this condition, it also demands that the ascension rate of the gamma-pulse be fast enough. For the different types of nuclear explosion, the latter condition can always be satisfied, and the former condition can also be satisfied within a definite spatial scope. Therefore, a nuclear explosion can definitely establish a saturation field, only there are differences in the size of the saturation field region.

(3) Saturation Field Boundaries: At the time of a nuclear explosion, the saturation field's circumference can rapidly expand with time, the maximum radius it can achieve is determined by the nuclear explosion equivalent and environmental parameters (primarily air density), the saturation radius R_m can be estimated using Equation (27), under the practical units system it is:

$$R_m^2\exp(R_m/\lambda)\leqslant eLN/4\pi\lambda E_{0s}\varepsilon_0=4.5\times 10^{-16}N$$

For comparison, suppose a different equivalent is an explosion at the same altitude, the relationship of the saturation radius and the explosion equivalent is as illustrated in Table 1.

Table 1. Maximum Saturation Field Radius of Different Nuclear Explosion Equivalents

Nuclear explosion equivalent (kT)	1	10	10^2	10^3
Maximum radius of saturation field (km)	0.99	1.41	1.96	2.51

3. Transitional Region

Theoretically, the saturation field has a boundary, but it is very difficult to determine this boundary in actual experiments. On the one hand, the indefiniteness of the [explosion] equivalents and the environmental parameters directly affect the size of the anticipated saturation field region, and on the other hand, the electric field values near the boundary are constantly changing, but the waveforms outside the boundary do not have clear changes. However, as far as the shape of the waveforms of the transitional region, the waveforms of the region's radial field are as illustrated in Figure 7, they no longer have the characteristics of the saturation field but exhibit a forward pulse. The relationship of decay with distance is very rapid, similar to the case of gamma rays. At the same time, the characteristics of the radiating field are also clearly manifested. When the distance increases to a certain value (several km), the characteristic radial field forward pulse also no longer appears, and the waveforms measured are entirely radiating field signals.

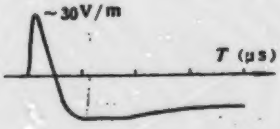

Figure 7. EMP Waveform of Atom Bomb Explosion Measured at 1.6 km

4. Radiating Field Region

In addition to the source region, within the range of nearly 100 km, the radiating field signals can also clearly reflect some characteristics of the nuclear explosion process. As the propagation distance increases, the high frequency portion decays very fast, these characteristics gradually disappear, therefore the radiating region of interest is the region within 100 km. Figure 8 gives the measured waveforms of several typical radiating fields. (a) and (b) are the results of measurements at 6.6 km and 35 km, respectively, from the same atom bomb explosion; (b) and (c) are the measurement results at roughly the same distance of two different explosion equivalents [(b) is kT level, (c) is MT level]. These typical waveforms show that:

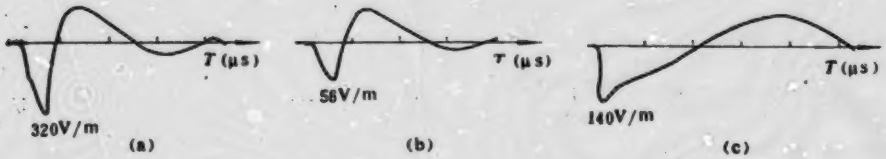

Figure 8. Diagram of Several Typical Observed Radiating Field Waveforms

(1) The EMP radiating signals of any atom bomb explosion are made up of three quasi half periods, the first half period being the negative pulse.

(2) For explosions at the same altitude, the peak value and the width of the radiating signal's first half period does not rely sensitively on the explosion equivalent. When the equivalent increases, there are slight increases in the peak value and the width.

(3) The decay of the radiating signal with distance is much slower than the radial field, approximating an inverse proportional relationship, and within 100 km, the waveforms do not generate obvious distortion, therefore radiating signals can be observed at very great distances.

(4) The asymmetry of the nuclear explosion environment severely influences the structure of the radiating signal. Changes in atmospheric density with altitude and the surface influences only affect the size of the signal and the detail of the waveform but cannot change the basic shape of the signal.

5. Frequency Spectrum of Nuclear Explosion EMP

Carrying out Fourier transformation of the EMP waveforms obtained, we can obtain its frequency spectrum distribution. Figure 9 is the frequency spectrum curve obtained from measurement, (a) was obtained from the source region field waveform and (b) was obtained from the radiating field waveform.

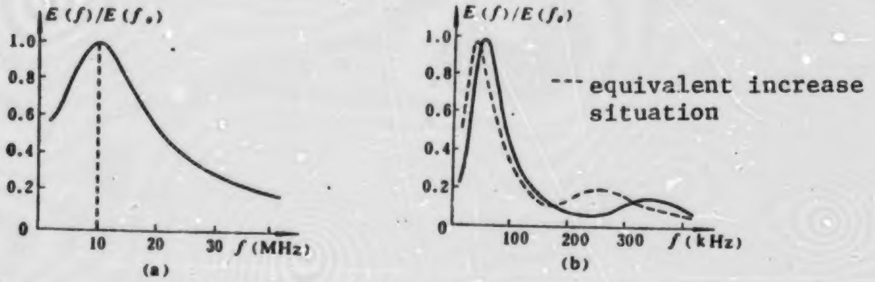

Figure 9. Analysis of Nuclear EMP Frequency Spectrum

The energy of the source region field is primarily concentrated in the 1-100 MHz band, its basic frequency being about 10 MHz. It should be pointed out that Figure 9A) only shows the frequency spectrum of the source region signal's high frequency part, actually the low frequency part of the signal is rather large, this is because after the characteristic radial field pulse, a negative pulse of long duration and large magnitude appeared. Clearly, this pulse contained very high electromagnetic energy, its low frequency lower limit may be as low as several tens of Hz. For this reason, in terms of the entire source region EMP, the frequency element is rather rich.

The frequency spectrum of the radiating EMP signal is limited to a very narrow pass band below 500 kHz, the basic frequency range is between 20 kHz and 50 kHz, there is a definite relationship between its numerical value and the nuclear explosion equivalent: as the equivalent becomes larger, the basic frequency becomes lower. As the propagation distance increases, the high frequency element in the radiating signal gradually decays, becoming closer and closer to a lightning waveform. For hydrogen bomb explosions, the high frequency element of radiating signals within 100 km clearly increases. On the basis of this characteristic, the type of nuclear explosion can be distinguished over very long distances.

Here it would be explained that research on nuclear EMP is a topic which covers a very broad range, and the tests in this paper were based on the research results of many comrades over a long time. Here we would like to express our heartfelt gratitude to these comrades.

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CHINESE NUCLEAR DATA ACTIVITIES OUTLINED

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[Article by Li Shounan [2621 1108 8538], Institute of Atomic Energy, Beijing: "China's Progress in the Nuclear Data Field"]

[Text] Abstract. China has made great progress in the nuclear data field since the 1960's. The Nuclear Data Center was established in 1975. With the cooperation of personnel in nuclear physics and the relevant departments throughout the country, two stages of a nuclear data evaluation project have been completed, some important nuclear measurements have been made, efforts have been made to provide suitable experimentation and measurement capabilities, and the computerized "China Evaluated Nuclear Data Library, Edition 1" (CENDL-1) is nearing completion. This article describes China's progress in the nuclear data area and offers some suggestions for further work.

1. Introduction

Nuclear data are the basic information that is utilized in nuclear power production and is applied in nuclear technology. As nuclear science and nuclear power have developed worldwide, great importance has been attached to nuclear data activities; prolonged, major efforts have been made in nuclear measurements, theoretical calculations, and compilation and evaluation. Some of the leading countries in nuclear power have set up their own nuclear data organizations and data bases. The International Atomic Energy Agency's Nuclear Data Section [IAEA/NDS] is in charge of organizing international exchange and cooperation in the nuclear data field. This field is already a major area of international exchange and cooperation and an important measure of achievement in nuclear power applications.

Below we outline China's progress in the nuclear data area.

2. Establishment of the Chinese Nuclear Data Center

a. China gradually acquired a capability for experimental research in low-energy nuclear physics during the late 1950's and early 1960's. In the mid-1960's, in response to the development needs of the nuclear industry, Chinese nuclear physicists carried on a series of experimental projects to acquire data, performed various pressing tasks, established a certain experimental capability, mastered experimental techniques, and trained scientific and technical personnel, thus making a definite contribution to domestic work in neutron physics, fission physics, and the reactions of light nuclei.

b. During the 10 turbulent years, work was temporarily suspended. China's nuclear physics personnel gradually began a recovery in 1972-1973. In 1973, in the process of drafting an 8-year plan, the Institute of Atomic Energy drew up a specialized plan for nuclear data activities which set the militant objective of establishing China's own nuclear data system within 8 years or slightly longer [1]. Based on the needs of experimental nuclear physics and nuclear measurements, it put forward a plan for the modernization or reconstruction of accelerators [1] as white neutron sources for nuclear measurements and in addition called for the design and construction of a 100 meV high-current short-pulse linear electron accelerator [1]. In order to raise the standards of nuclear research and provide supplementary neutron sources in the 8-13 MeV range and higher, it was decided to import a 2 x 10 MeV cascaded electrostatic generator [1], and in order to meet the needs of theoretical calculations and the creation of nuclear data bases it was decided to import a computer capable of performing 1 million operations per second [1].

c. China's first nuclear data conference was convened in December 1973 for exchange of information on domestic nuclear measurements, international progress on nuclear data, and the nuclear data needs of China's nuclear power industry [2]. The conference led to a general recognition of the need for work in the nuclear data area and provided an important impetus for nuclear data activities.

d. In the spirit of this conference, the Institute of Atomic Energy established the nuclear data planning group at the beginning of 1974. Work began with a comprehensive survey of international nuclear data developments [3] and domestic needs [4] and an examination of nuclear data compilation and evaluation methods. In the measurement field, planning for a linear electron accelerator and a parallel static accelerator began in late 1973 and arrangements were made to measure $\bar{\nu}$ and σ_t for ^{239}Pu, the excitation curves for certain reactions, the gamma spectra and gamma ray production cross sections for neutron reactions, fission outputs, and the macroscopic characteristics of graphite.

e. The task of compiling and evaluating sets of neutron data was officially assigned in June 1975. The second nuclear data conference was held at the Institute of Atomic Energy in October 1975. The first stage evaluation project was organized and carried out and a 10-year plan for nuclear data activities was drafted [5]. The construction of the Ministry of the Nuclear

Industry's Nuclear Data Center was formally announced, a national nuclear data cooperation network was established, and nuclear data compilation and evaluation methods and the suitability of existing nuclear theoretical models for the computation of nuclear data were examined. After the Second Nuclear Data Conference, China's nuclear data activities entered a new stage.

3. Nuclear Data Activities After the Establishment of the Nuclear Data Center

3.1. Completion of Two Stages of the Nuclear Data Evaluation Project

Since the Second Nuclear Data Conference China has carried out two stages of a nuclear data evaluation project, which were examined and approved at the Third and Fourth Nuclear Data Conferences.

a. The task of the first stage was to provide evaluated and recommended data meeting 1970's standards, chiefly sets of neutron data on 16 nuclides. The first task was effectively completed in 1978 as a result of 2 and 1/2 years' work, providing sets of evaluated and recommended data on all fast neutron reaction paths for 16 radionuclides, including H, D, T, ^{6}Li, ^{7}Li, Al, Fe, ^{235}U, ^{238}U, and ^{239}Pu [7], and evaluated and recommended data on the yields of 33 nuclear reaction products from fission-spectrum neutrons and certain monoenergetic neutrons [3]. In addition, the excitation curves for 30 neutron reactions were measured and evaluated, and data were compiled, evaluated and recommended for the decay diagrams of 100 nuclides.

The cutoff point for recommended data was 1976. Our compilation included new data published after the completion of similar foreign works and ENDF/B-IV [Evaluated Nuclear Data File]. In general, owing to our analysis of the literature on experimental measurements and comparison of foreign evaluated data, our recommended data are rather reliable. The theoretical calculations were generally based on mature models. We conscientiously adjusted the relevant parameters and made system studies, with the result that most of the calculations agreed with experimental data and the figures were comparable in quality to international values obtained at that time by the same types of calculations.

b. The second stage of the project, completed in 1983, involved the following work:

Sets of data on all fast neutron reaction pathways for 21 nuclides including ^{10}B, ^{11}B, C, O, ^{23}Na, Mg, Si, V, Cr, Ni, Cu, Zn, Zr, No, Mb, Sn, Hf, Ta and Au were evaluated and recommended. The 37 sets of neutron data from the two stages of the project were stored in computer memory in the ENDF/B format (on tape) and the equivalents of the ENDF/B-IV files 1, 3, 4, and 5 were provisionally set up.

In order to expand the range of energies to the thermal region and to make preparations for files 2 and 7, we evaluated the resonance parameters for about 90 nuclides [8], evaluated the data on the scattering laws for thermal neutrons and investigated theoretical calculations. Thermal neutron-induced gamma ray output data for 75 nuclides and fast-neutron gamma ray output data for 27 nuclides were compiled and evaluated.

The decay data for about 257 commonly used nuclides were revised and evaluated [10].

Yield data on thermal neutrons and fast reactor spectrum neutrons for 22 fissionable isotopes including U and Pu and more than 200 fission products produced by monoenergetic neutron induction were revised [9].

Excitation curves for neutron-nucleus reactions of 30 isotopes [11] and excitation curves for charged particle-nucleus reactions of 18 isotopes were revised [12] and the excitation curves for 58 neutron-nucleus reactions were calculated from theory.

In addition, initial calculations were made of nonelastic discrete energy level cross sections, angular distributions and secondary neutron spectra for uranium and plutonium isotopes. Various data on transplutonium nuclides, reaction cross sections for reactions between charged particles and light nuclei, absolute delayed neutron yields, photonuclear reactions and photofission as well as standard data were compiled and evaluated.

The evaluated and recommended nuclear data from the second stage of the project were of good quality. The experimental data were taken from EXFOR 80-81, obtained from IAEA/NDS, and were supplemented from the 1982 CINDA [Computer Index of Neutron Data] and the most recent data from journals. As a result, our data included 1973-1981 experimental figures not available in ENDF/B-IV. Some of the data were from our own theoretical calculations; in the theoretical calculations the parameters were adjusted carefully, and most of the results agreed with experimental data. Some of the data were supplemented from ENDF/B-IV and INDL/V. These data have already been entered in the data base as needed and are available for use.

3.2. Establishment of Computerized Data Bases

The use of computers for nuclear data evaluation and the establishment of nuclear data bases began in 1980. In 1983 the data center installed a PDP 11/70 computer system for the nuclear data base and for evaluation; both evaluation and data base creation have gradually been transferred to this system. The main work done prior to 1984 included the following:

a. A nuclear experimental data base. The retrieval program was set up on an ACOS-500 machine and the experimental data in the EXFOR data format obtained from IAEA by exchange has already been made available for use.

b. An evaluated nuclear data base. The management program system was established on a FELIX-C512 machine, and the sets of neutron data for 37 nuclides obtained during the first two project stages have already been included in the data base, stored on tape in the ENDF/B format. The computerized China Evaluated Nuclear Data Library, First Edition (CENDL-I) is nearing completion [13].

c. An interactive computerized nuclear data evaluation system was developed and set up on an ACOS-500 machine and has been used in evaluating neutron data for 21 nuclides.

d. A resonance parameter testing system has been provisionally installed on the PDP 11/70 machine.

Thus the computerized nuclear data base is already in a fledgling state; the computers are being used for nuclear data evaluation, nuclear data tapes are being used for international exchange, so that a preliminary capability for meeting domestic needs is now in place.

3.3. Generation of Group Constants and Macroscopic Testing of Nuclear Data

In order to meet the urgent needs of reactor engineering, the nuclear data center has organized the relevant units for joint compilation of a set of micro-scale data for 30 nuclei commonly used in reactor engineering [14] and has used the data to generate group constants for 9 elements for reactor use [15].

The Beijing Institute of Applied Physics and Computational Mathematics has set up a preliminary neutron group constant processing system (NGCPS) [16] and has used the evaluated nuclear data from the first stage of the project to generate group constants and test them.

The data center, in cooperation with other units, has established a thermal reactor group constant program (RQCS) [17], has produced 68 group constants for 54 groups of 9 nuclei as well as 25 group constants for shielding, and has established a fast group constant production program (KQCS) [18].

In the area of macroscopic testing, a one-dimensional discrete-coordinate anisotropic scattering SN program (DSNF) has been created and a Carlson SN program for scattering [19] have been installed and used to test evaluated data for ^{235}U, ^{238}U, ^{239}Pu, Fe and Na. A one-dimensional diffusion program (NDP) [20] and a two-dimensional diffusion burnup program (TDBDC) [21] have been installed; their computation results have agreed well with 14 U.S. reference test results.

The Southwest Nuclear Physics and Chemistry Research Institute has established a reference device for testing depleted uranium pellets and has performed macro-scale experiments on D-D neutrons, 14 MeV neutrons, and ^{252}Cf neutrons with it; the device is already being used to test the first stage nuclear data, measurement results are now being obtained [22].

The Institute of Atomic Energy has also established an isotropic reference fast neutron field in a swimming pool reactor thermal column [23]. This work has given us an initial nuclear data testing capability and has provided certain capabilities for further testing of CENDL-1.

3.4. Theoretical Calculation of Nuclear Data

The theoretical calculation of nuclear data has an important role in the evaluation process. Such data as σ_f, σ_t, low-energy $\sigma_{n\cdot r}$, ν [nu] and the like can largely be provided from experimental data supplemented by theoretical calculations, but other data such as energy spectrum angular distributions and (n, 2n) and (n, 3n) data and the like must largely be obtained by calculation.

In the first stage of the project mature international modeling theories and methods were used to calculate nuclear data. These data are brought together in the book "He Fanying Lilun Fangfa Ji Qi Yingyong Wenxuan" [Collected Papers on Theoretical Methods in Nuclear Reactions and Their Applications] [24]. The theoretical framework for nuclear data that was established during the first stage of the project focused primarily on standardization and format unification of computation programs for medium and heavy nuclei. Nankai University undertook the task of compiling the Unified Data Computation Program for Medium and Heavy Nuclei [25], which combined the optical model, the H-F statistical theory, the evaporation model and the exciton model; with the cooperation of the data center and Wuhan University it has been completed and put into use. Because of the advances in nuclear data work, good progress has already been made in such basic research areas in nuclear theory as microscopic optical potentials, fission mechanisms, three-body reactions, and radiative capture. The two-exciton cross section theory developed by us, which uses exciton model calculations, is already usable for nuclear data calculations [16] and has been used internationally.

3.5. Improvement of Nuclear Measurement Capabilities and Progress in Measurements

a. Since 1973 the Institute of Atomic Energy has used existing capabilities to make certain nuclear measurements such as the value of $\bar{\nu}$ for ^{239}Pu and ^{252}Cf and the value of σ_f for ^{239}Pu, attaining rather high precision [27-29]. By combining the measurement, compilation and evaluation of excitation curves for neutron-nucleus reactions, a set of rather high-quality evaluated data has been recommended [30]. The absolute yield figures for ^{99}Mo in fission of ^{235}U initiated by thermal neutrons and fission-spectrum neutrons still contain some disagreements [31]. Secondary neutron energy spectra and angular distribution data for certain nuclei with 14 MeV, 11.6 MeV and 8.6 MeV neutron have been measured [32]. The (n, n'γ) reaction cross sections and gamma spectra for the elements C, F, Mg, Al, Si, Cu, Ni, Pb and Bi for 14 MeV neutrons have been measured [33].

b. Sichuan University's Institute of Nuclear Science and Technology used a nanosecond-pulse modulation high-voltage multiplier and a static accelerator to measure neutron elastic scattering cross sections and angular distributions. Jilin University and the Institute of Atomic Energy used a Ge (Li) gamma spectrometer to measure decay diagram data for certain nuclei. Qinghua University has performed research on small-angle neutron scattering. Beijing University has measured inelastic scattering cross sections.

c. The Institute of Atomic Energy's HI-13 parallel static accelerator is likely to begin operation in 1985. A special neutron chamber has been established for nuclear measurements; it is equipped with a neutron time-of-flight recorder, a general-purpose neutron target chamber, a gamma ray angular distribution meter and a fission target chamber.

When the parallel accelerator is completed, it will provide a good pulsed neutron source. It will then be possible to measure angular distributions and energy spectra for neutron scattering, wide-energy-range (n, 2n) and (n, 3n) cross sections and the like, which will be extremely important in supplying missing data for the 8-13 MeV range.

3.6. International Exchange and Cooperation

International exchange and cooperation in the nuclear data area have gradually expanded since 1978. Chairman of the Japan Nuclear Data Commission and Chairman of the Physics Division of the Japan Atomic Energy Institute K. Tsukada, Deputy Director of the U.S. national data center S. Pearlstein, Dr K. Okamoto of the International Atomic Energy Agency's Nuclear Data Section, and Chairman of the U.S. Oak Ridge RSIC B.F. Maskewitz have visited China to lecture and to study exchange and cooperation.

The Institute of Atomic Energy has sent personnel to Japan to investigate nuclear data work there, as well as to an international nuclear data conference in Antwerp and to the Geel and Harwell laboratories.

As a result of these activities we have established preliminary exchange and cooperation ties and have obtained valuable international experience and some valuable data. In addition we have set up a cooperative nuclear data evaluation system with the United States National Nuclear Data Center (NNDC), we have signed an agreement for data evaluation studies on transplutonium nuclei with IAEA/NDS, and we have investigated cooperation in fission yield evaluation and data base creation.

In 1983 China joined the IAEA and the Ministry of the Nuclear Industry's Nuclear Data Center was officially named the "China Nuclear Data Center." In 1984 China sent observers to the 10th International Nuclear Data Committee session and was received as a regular member of the committee; thus our nuclear data activities and international exchange and cooperation relationships entered a new stage.

4. Further Development of Nuclear Data Activities

Chief among China's future tasks in the nuclear data field are increased completeness and improved quality.

a. We must make CENDL-1 more complete and upgrade it. We need to complete a collection of neutron reaction data equivalent to files 1-7 of the ENDF/B data base, suitably expand the complete neutron data sets for certain nuclei in order to expand their usability, and strive to supplement the neutron-gamma production data in files Nos 12-16 and covariance file 33. This requires the following:

(1) In the area of theoretical calculations, we must improve the unified fast-neutron data calculation program for medium and heavy nuclei, e.g., by allowing for multiparticle emission processes, direct interaction and the deformed-nucleus optical model. We must then proceed to establish a multi-function unified standard program and focus on investigating and establishing theoretical methods and programs for calculating data for 19 light nuclei and gamma production data (including cross sections and energy spectra). We must gradually establish standardized program libraries for theoretical calculations.

(2) We must rewrite the nuclear data evaluation program, the experimental data base and the evaluation data base on the PDP 11/70 computer, as well as the relevant management program system. We should improve the international compatibility of the data base.

(3) We must establish a group constant program for reactor use, connected with the nuclear data base, and use CENDL-1 to generate group constants for practical use.

b. We must focus on experimental research on microscopic data, use the cascaded electrostatic generator to perform nuclear measurements, particularly in the 8-13 MeV neutron energy range, speed up the building of high-current short-pulse linear electron accelerators, and designate certain high-voltage multipliers for conversion into nanosecond-pulse modulators.

We must use the multipliers, electrostatic accelerators and cyclic accelerators to obtain data that is lacking and important nuclear data on which there is disagreement, as well as absolute measurements for single-energy points. We must strive to increase measurement precision.

We must continue measuring ^{235}U fission yields for fission-spectrum neutrons and clear up disagreements.

The data center must draw on its evaluation activities to suggest specific measurement tasks so as to make full use of existing capabilities and develop measurement activities.

c. We should intensify macroscopic experimentation and nuclear data testing; the data center should set up computer programs linking the CENDL-1 data base and the group constant production programs as rapidly as possible, as well as programs linking the group constant programs and programs for calculating integral quantities; and we must use reference experimental data to test the CENDL-1 data. We must make a vigorous effort in the evaluation of reference testing, make thorough use of reference devices and conduct integral experiments.

d. We must actively participate in all of the IAEA Nuclear Data Section's organizations and all specialized activities arranged by it, intensify cooperation with other nuclear data centers, intensify publications activity, suitably organize our personnel, and expand certain areas, such as radiation damage data for fusion reactor materials and atomic-molecular data. We must thoroughly utilize favorable international conditions to speed up the upgrading of China's nuclear data standards.

e. We must establish a China nuclear data committee as soon as possible to modernize and strengthen guidance of our nuclear data activities.

International nuclear data activities have been broadening and deepening, and their range of application is constantly expanding. Nuclear data bases require timely updating; China's nuclear data activity must include systematic research and long-term planning, and work in important areas must gradually be deepened.

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8480/6091
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APPLIED SCIENCES

NUCLEAR TRACK CODE TECHNIQUES

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 4, Jul 85 p 62

[Article by Meng Wu [1322 2976], Institute of Atomic Energy, Chinese Academy of Sciences: "Nuclear Track Code Technique"]

[Text] Many measures are used to prevent forgery but these methods all can be copied. Can we find a marker method which cannot be reproduced? This aim can be achieved by using fixed track technology. This method has important significance for making classified documents, printing revalued currency, authenticating objets d'art and safeguarding the prestige of brand name goods.

1. Principles: A fixed track is an etched pit which appears in a microscopic field after a track produced by charged particles in a dielectric solid is chemically etched. Using these etched pits (i.e., tracks) one can create many forms and types of nuclear security codes. In terms of their nature, they can be divided into two kinds: dark codes and light codes. The dark codes can be either colored or colorless by use of a developer. Below we combine a description of several practical applications with their principles.

(1) Position marker method: a mark is placed in a certain position on papers using the colorless developer or several characters can be written using the color developer, papers treated in this way can be distinguished from forgeries, and when it is necessary to tell them apart, using a fixed track detector plate at the location of the mark, radiate it in a thermal-neutron field for 20 seconds, then remove the detector and after etching, observe it under a microscope to distinguish true from false papers.

(2) Content marker method: Although in the above method three place numbers can be used to make up thousands of papers which can be distinguished from each other, it is easy to break the code. But the content method does the marking using a special content discharger, so that not only does the position of the mark change, but the content changes as well, and this makes it very difficult to copy.

(3) Statistical marker method: We know that nuclear events have a statistical nature, that is, using the same source and target, there could never be the same track distribution, and utilizing this quality, we can make a nuclear code which cannot be copied.

2. Experimental results and discussion: Experiments have been made on all three of the above described methods and the results show that they are feasible.

The nuclear track code technology introduced in this paper actually uses charged particle tracks to form numerals, symbols, pictures, and characters. It is different from ordinary security code microscopic dots. After being developed chemically ordinary security code microscopic dots can be appropriately magnified and reproduced or altered but nuclear tracks are damage tracks of charged particles in a solid state, and their form is extremely difficult to reproduce.

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PROGRESS IN ION-BEAM FUSION RESEARCH REVIEWED

Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 5 No 3, Sep 85 pp 269-276

[Article by Wang Naiyan [3769 0035 1750], Institute of Atomic Energy, Beijing: "Progress in Ion Beam Inertial Confinement Fusion Research"]

[Text] Progress in particle beam fusion research and key problems still awaiting solution are outlined. A light-ion beam is a potentially ideal driver for inertial-confinement fusion because the pulsed power source for producing light ions is cheap and highly efficient. Research on diodes capable of efficiently producing a high-brightness ion beam is described. The stopping power for light-ion beams has been calculated, taking account of both electrons confined in the target and free electrons. Experimental results show that when the current density of the beam is relatively high, the stopping power is twice that for a cold target. Implosion research is under way and cylinder implosion experiments have been performed.

Research on fusion by inertial confinement with a light-ion beam began in the 1970's and has developed rather rapidly; it is now being vigorously pursued in such countries as the United States and Japan. The main reason for the hopes reposed in light-ion beam fusion is that such beams can be produced with high efficiency. The efficiency of the conversion from electric power to ion beam power may be as great as about 30 percent and the energy deposition behavior in the target is highly satisfactory: the range is short and the maximum energy deposition per unit path length occurs near the end of the trajectory, so that when an ion beam strikes a target there is no problem of preheating of the central thermonuclear fuel; in addition, compression of the time interval which a nonrelativistic ion beam takes to cover its flight distance increases the power density of the beam. But there are many problems in achieving burn, primarily involving ion beam transmission and focusing, so that for the near term, efforts are focusing primarily on pulse power compression, increasing beam brightness and decreasing beam divergence so as to increase the irradiation power density per unit area of target. Below we discuss progress in international ion-beam fusion research and the main problems involved.

1. Beam Requirements for Ion-Beam Inertial Confinement Fusion

According to theoretical calculations, in order to attain the break-even condition, the ion beam energy deposition in the ablation layer must be 1×10^7 J/g; the speed with which the layer is propelled and the thermonuclear fuel is compressed must be 2×10^7 cm/sec. Specifically, for a target pellet with a radius of 1 mm, the total energy of the particle beam must be in the megajoule range, the beam power must be about 100 TW, and the power density at the target must be about 10^{14} W/cm^2.

With 36 target impact paths, the power density at the target is related to the beam power density D as follows:

$$P = B \cdot K \cdot \delta \qquad (1)$$

where B is defined as

$$B = \frac{\text{beam power density}}{\text{vertical microscopic divergence X horizontal microscopic divergence}}$$

For convenience of discussion we assume that the vertical and horizontal microscopic divergence angles are both equal to $\Delta\theta$, with $\Delta\theta \sim \frac{r}{D}$, where r is the radius of the target and D is the distance between the beam source and the center of the target; accordingly the solid angle $\Delta\delta$ which the ion emission source subtends at the target center satisfies the condition

$$\Delta\delta = \frac{S}{4\pi r^2} = \frac{S_0}{4\pi D}$$

where S_0 is the surface area of the emission source and S is the irradiated surface area of the target.

The beam power per unit area on the irradiated target is $\frac{S_0 JV}{S} = \frac{JV}{(\Delta\theta)^2}$, where J is the ion beam intensity and V is the ion energy. $\frac{IV}{(\Delta\theta)^2}$ is called the beam brightness; its physical meaning is the beam power incident on a unit area of the target. Obviously, in order to achieve burn the beam brightness must be 10^{14} W/cm$^2 \cdot$sr or more.

Experiments have shown that a foil converging reflector diode has a current density of 3-30 kA/cm^2 [1], while with an impressed magnetic field diode the current density is between 7 and 35 kA/cm^2 [2]. Even in those ranges the beam divergence was independent of the current density, so that large current densities help increase beam brightness and the two quantities are essentially in a square relationship. The calibration relationship between the beam brightness and the voltage is attracting the most attention, because increasing the voltage V also decreases $\Delta\theta$, and it has been demonstrated with the limited data currently available that the beam brightness is proportional to V^2 [3] (see Figure 1). With a 1.8 MeV proton current the same brightness is 10^{13} W/cm^2-rad^2, still an order of magnitude below the burn requirement, so that burn can be achieved by increasing the voltage and decreasing the divergence.

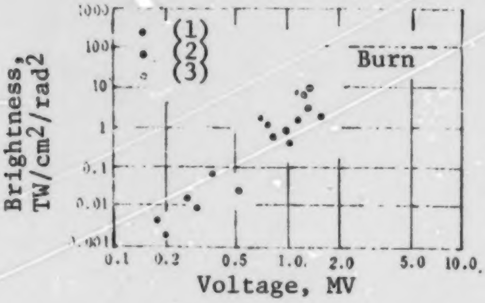

Figure 1. Calibration Plot of Beam Brightness vs. Voltage for Three Diode Types

Key:

1. Applied magnetic field
2. Automatic injection magnetized plasma
3. Foil condensing reflector

The beam divergence angle $\Delta\theta$ is determined chiefly by the following factors:

a. Polarization of the ion beam in a non-magnetically-neutral zone. When designing the ion beam diode, every effort must be made to decrease the non-neutralized magnetic field in the ion current transmission area and to decrease the length of the path through a nonneutralized region that the ions must travel, which is equivalent to decreasing the transit time. Accordingly, increasing the voltage to increase ion energy and using ions with large mass will decrease the effect of the nonneutralized region on the directional deviation of ion motion, and thus it is advisable to use ions with a small charge-to-mass ratio.

b. The filamentary instability that occurs in the ion beam in the acceleration gap partly changes the space charge distribution and produces angular and radial electric fields, thus increasing the divergence angle.

c. Instabilities produced by interaction with the cathode plasma when the ion beam passes through the electron cloud, and the effect of intrinsic gas scattering on the divergence angle.

d. The effect of nonuniformities in the anode plasma.

Summarizing the above, the light-ion beam driver must have the following characteristics: 1) large accelerating voltage; 2) high beam density; 3) large deflecting magnetic field; 4) magnetically neutral beam transmission; 5) medium-mass ion beam.

2. Research on Ion Beam Diodes

In order to develop diodes suitable for burn requirements, the main focus worldwide is on three types of ion beam diodes, namely the foil condensing reflector diode, the impressed magnetic field diode and the automatic injection magnetized plasma diode. The last-mentioned of these types is being developed most rapidly. The design and operating principles of this diode are shown in Figure 2.

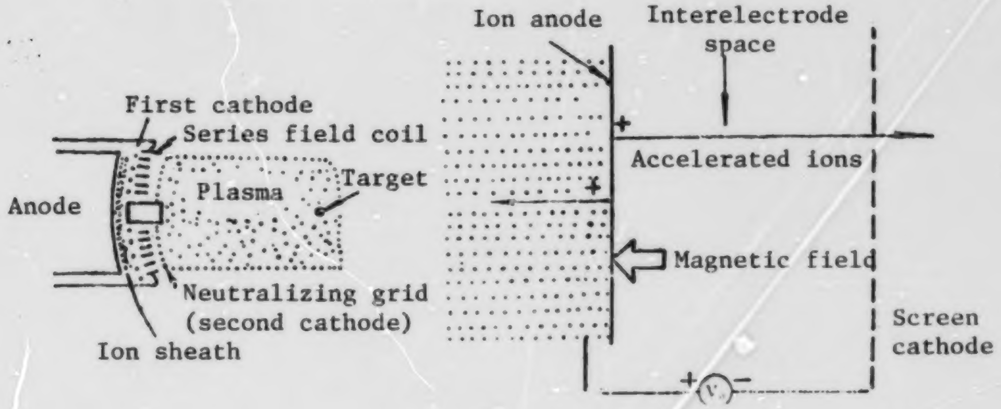

Figure 2

A plasma is first injected into the gap between the anode and cathode; the ions are pulled out of the plasma. The anode is in direct contact with the plasma, while the cathode has a triple grid structure: the first cathode, the series field coil and the second cathode. The series field coil is located between the cathode and anode; a current flowing through this coil produces a magnetic field component parallel to the electrodes, so that a magnetic potential is applied to the anode plasma, which moves it to the left, producing an acceleration gap whose size increases over time. As a result, the resistance and voltage of the diode also increase over time, which has the effect of focusing the beam. After the ion beam passes through the field coil and reaches the second cathode, it acquires electrons from the plasma in the drift area, so that the beam is neutralized; for this reason, the second cathode is often called the "neutralizing cathode." Because the magnetic field increases in pulsed fashion over a short time interval, it cannot penetrate the drift area, so that the transmission in the drift area is beam neutralizing transmission. In addition, this diode has the ability to select the ions that are accelerated; it accelerates only ions with a small charge-to-mass ratio [4]. Experimental results [4] indicate that the ion beam divergence is small and the focusing is good (see Table 1).

The divergence for Li^{2+} ions is smaller than that for H^+ ions, indicating the benefits of selecting ions with a small charge-to-mass ratio. But the mismatch between the anode plasma production time and the voltage waveform time is much greater for Li^{2+} than for H^{+}, which hinders an increase in beam power. Accordingly the problem of producing a large-area spatially uniform plasma of suitable density and high purity that forms in the early part of the diode voltage pulse is critical to the quality of a high-current ion beam.

Table 1. Experimentally Obtained Emission Angles and Beam Brightnesses

	Horizontal divergence, mrad	Vertical divergence, mrad	Beam brightness, TW/cm^2-rad
Hydramite automatic injection magnetization plasma mixing diode (Li^{2+})	10	10	2
PBFA-1 automatic injection magnetization plasma mixing diode (H^{+})	25	27	1

3. Investigation of Ion Beam-Target Interaction

At low beam densities the beam's energy deposition in the target follows the classical laws. At high beam densities, because the degree of ionization in the target is high and the number of free electrons in it is accordingly increased, the target's ion stopping power will be higher than for a low beam density. Experiments have verified that the increase may be as great as a factor of 2. This intensification effect is still in accordance with the classical laws, but allowance must be made for the stopping power of the electrons. Because of the increased energy deposition, the requirements regarding beam density can be relaxed (at the time of burn).

The Naval Research Laboratory has used a foil condensing reflector diode in the Gamble-II accelerator to produce 1.2 MeV deuterium ions that strike a 6.4-μm Mylar film and a 6-μm aluminum film, to the front and back of which 0.3 μm and 1 μm CD_2 plates are bonded to measure the deuterium ion energy at the front and back of the target (see Figure 3). The neutron time of flight method is used to detect the neutrons from the D-D reaction, making it possible to calculate the deuterium's energy and determine its energy loss in the target [5]; the experimental results are shown in Figure 4.

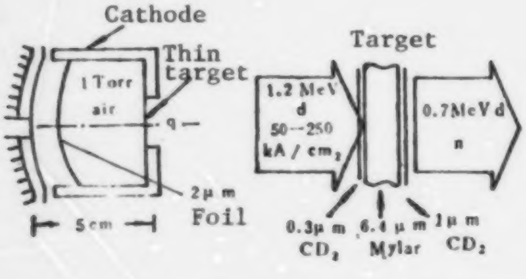

Figure 3

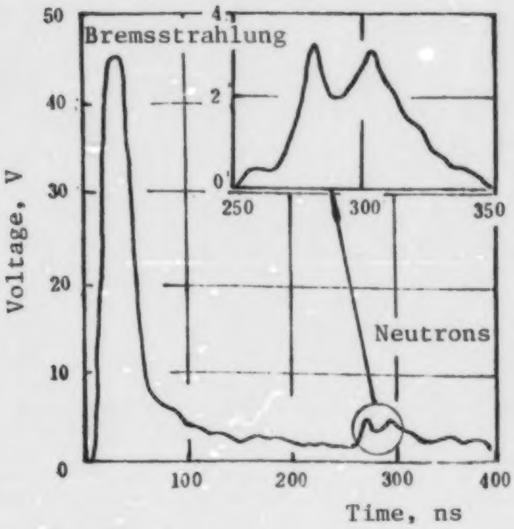

Figure 4

The target temperature is measured with an X-ray diode and the Saha equation is then used to calculate the degree of ionization of the target, which makes it possible to calculate separately the stopping powers of bound electrons and free electrons:

for bound electrons, $\left(\frac{1}{\rho}\frac{dE}{dx}\right)_b \doteq 143\frac{A_1 Z_1^2 Z_2}{E A_2}\ln(\Lambda_b)$

for free electrons, $\left(\frac{1}{\rho}\frac{dE}{dx}\right)_f \doteq 143\frac{A_1 Z_1^2 Z_2}{E A_2}\ln(\Lambda_f)$

$$\Lambda_b = 109\frac{E}{A_1 Z_2^{0.82}}, \qquad \Lambda_f \doteq 59\,E A_2^{\frac{1}{2}}/[A_1(\rho \overline{Z}_2)^{\frac{1}{2}}]$$

$$\overline{I} = 2\times 10^{-5} Z_2^{0.82}$$

where A_1 and Z_1 are the atomic weight and atomic number of the ions incident on the target and A_2 is the atomic weight of the target atoms. The target's total stopping power for the ions is

$$\left(\frac{1}{\rho}\frac{dE}{dt}\right)_t \doteq 143\frac{A_1 Z_1^2 Z_2}{E A_2}\left[\frac{Z_2-\overline{Z}_2}{Z_2}\ln(\overline{\Lambda}_b) + \frac{\overline{Z}_2}{Z_2}\ln(\Lambda_f)\right]$$

$$\overline{\Lambda}_b = [(Z_2-\overline{Z}_2)/Z_2^{1.18}]\Lambda_b$$

the average ionization potential is

$$\tilde{I}(\bar{Z}) \doteq [Z/(Z-\bar{Z})]^2 \bar{I}(Z-\bar{Z})$$

the path length in a cold target is

$$R_c \doteq 5 \times 10^{8} \frac{A_2 E^2}{A_1 Z_1^2 Z_2 \ln(\Lambda_s)}$$

while in a highly ionized target material it is

$$R_i \doteq 5 \times 10^{-8} \frac{A_2 E^2}{A_1 Z_1^2 Z_2 \ln(\Lambda_f)}$$

Theoretical calculations indicate that for highly ionized target materials with low values of Z, such as H^{+1} (energy 3 MeV), He^{+1} (12 MeV), Li^{+2} (26 MeV) and C^{+4} (62 MeV), the range is 10 mg/cm^2. Given the requirement that a unit mass (in grams) on the target surface must absorb 10^7 J of beam energy, and assuming an ion beam width of 10^{-8} sec, the beam intensities incident on a unit target area needed to achieve the break-even condition are shown in Table 2.

Table 2. Beam Intensity on Target for Break-Even Condition

Characteristic	Type of ion			
	H^{+1}	He^{+1}	Li^{+2}	C^{+4}
Energy, MeV	3	12	26	64
Accelerating voltage, MV	3	12	13	~16
Beam intensity at target, kA/cm^2	3.3×10^3	8.3×10^2	3.9×10^2	1.6×10^2

4. Investigation of the Ion Beam-Driven Fusion Process

The experimental implosion layout is shown in Figure 5 [6, 7]. The proton beam peak energy is 1.5 MW, the peak current is 360 kA and the target temperature achieved is about 7 eV (peak). To allow small-aperture photography, a conical target is used. A small-aperture photograph is shown in Figure 5 (left). A cylindrical target is used in actual implosion experiments; four ruby laser holographic interferometers are used to measure the speed of the cylindrical target when irradiated by the ion beam: a slit photograph of the position of the imploding cylinder's interior surface is taken every 11 nsec, making it possible to determine the speed of movement of the interior surface. The results are shown in Figure 6 [3]. M.M. Widner and S.L. Thompson used the

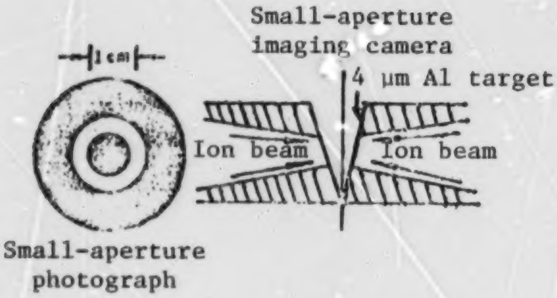
1 cm
Small-aperture imaging camera
4 μm Al target
Ion beam
Ion beam
Small-aperture photograph

Figure 5. Experimental Layout for Ion Beam Impact on Target

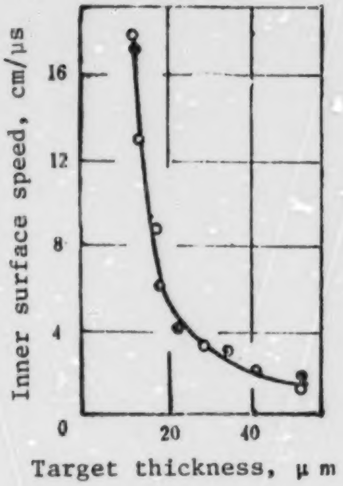

Figure 6. Measured Rear Surface Speeds

Proton flux power density on target 0.56 TW/cm^2
Al cylinder 6 mm in diameter
Dark circles indicate holographic measurement results
Light circles indicate calculated values from fluid mechanics program
Proton path length in target 15 μm

CHARTD program [9] to calculate a rear surface speed of $v = 4.5 \times 10^6 \ln \left|\frac{T}{T-15}\right|$ (where T is the thickness of the target in μm); this is called the "rocket model." The calculation results agree very well with the experimental figures; naturally T must be greater than the range R. Experiments have shown that for targets of the same thickness, v is proportional to $I^{0.5}$. i.e., the greater the incident ion flux, the faster the rear surface speed v. Using the one-dimensional fluid-mechanical equation and the continuity equation

$$\begin{cases} m_i n \left(\frac{\partial}{\partial t} + v \frac{\partial}{\partial z}\right) v = -KT \frac{\partial n}{\partial z} \\ \frac{\partial n}{\partial t} + \frac{\partial (nv)}{\partial z} = 0 \end{cases}$$

we obtain

$$v(t) = v_{ith} \mathrm{en}\left[\frac{m_0}{m(t)}\right], \quad v_{ith} = \sqrt{\frac{2KT}{m_i}}$$

$$m(t) = m_0 - t\frac{dm}{dt}$$

Thus v(t) changes over time, increasing as the implosion process develops. The rear surface velocity plotted in Figure 6 is for the time at which the rear surface has moved to half the central distance.

The kinetic energy of the rear surface is

$$\frac{1}{2} m(t) v^2(t) = \frac{1}{2} m(t) v_{ith}^2 \left\{\ln\left[m_0/m(t)\right]\right\}^2$$

The proportion of the incident ion beam energy that is converted to kinetic energy of the moving layer is

$$\frac{m(t) v^2(t)}{2E_p} = \frac{1}{8} \frac{m(t)}{m_0 - m(t)} \left[\ln \frac{m_0}{m(t)}\right]^2$$

the maximum energy transfer (about 8 percent) is achieved when $m_0/m(t) = 5$.

Research on ion beam-driven implosions has made relatively little progress to date. In the future every effort will be made to increase beam power, i.e., to maximize the energy of the accelerated particles and minimize the time width of the compression pulse (e.g., by developing lithium ion diodes that operate at 20-30 MV), as well as to increase beam brightness, improve the angular symmetry of the beam and use new technologies (such as plasma ablation switches and magnetically insulated transmission lines). It is forecast that the break-even point may be attained in 1987-1988.

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APPLIED SCIENCES

VISIBILITY OF TRANSVERSE CRACKS FOR RADIOGRAPHIC INSPECTION OF WELDS IN SPHERICAL VESSELS

Shanghai WUSUNJIANCE [NONDESTRUCTIVE TESTING] in Chinese Vol 6 No 5, Dec 84 pp 40-41, 39

[Article by Xue Jicheng [5641 4949 2110] and Xu Yadeng [1776 0068 3397] of the Jiangsu Electric Power Construction Company]

[Text] This article discusses several factors affecting radiographic inspection of transverse cracks in welds in spherical vessels and draws some conclusions concerning them.

Because of restraining conditions and residual stress from welding, welding seams in spherical vessels can have a rather serious tendency to crack if technical procedures are not strictly adhered to during assembly and installation. The cracks cause a loss of stability and can lead to leakage in spherical vessels, causing accidents.

The results of more than 10 inspections of spherical vessels that were opened indicate that transverse cracks are more numerous in spherical vessel welding seams and that they assume a pattern of radiation toward the center. They generally extend to a depth of 7 to 8 mm. The fact that they are cold cracks means that they can be rather wide. In terms of their distribution, there are more circular cracks than longitudinal cracks, and there are more of them in the inner walls than in the outer walls. This is especially true of the ease of their appearance in the circular seam that is the last to be closed. Moreover, most of them penetrate the width of the welding seams and enter the fusion line and the base metal of the spherical vessel.

There are many methods for nondestructive testing of spherical vessel welding seams to prevent accidents, and each has its own characteristics. This article mainly will discuss factors that affect the use of radiographic methods to make such cracks visible.

I. Direction of Cracking and Effects on Visibility

In the welding seam shown in Figure 1 with a width x and a linear attenuation coefficient of μ, there are three cracks of similar length that run in different directions. When parallel monochrome ray transillumination is used, the ray attenuation law applies, and we can derive:

$$I_1 = I_0 e^{-\mu x} \qquad (1)$$

$$I_2 = I_0 e^{-\mu(x-\Delta x)+\mu\cdot\Delta x} \qquad (1a)$$

$$\frac{I_2}{I_1} = e^{(\mu-\mu_1)\Delta x} \qquad (1b)$$

I_1--the intensity of the rays after passing through a welding seam of thickness x.

I_0--the intensity of ray incidence on the welding seam surface.

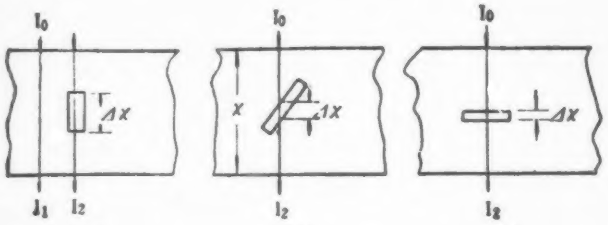
I_2--the intensity of the rays after passes through welding seams in the area of the defect.

e--the lower natural logarithm, which is roughly equal to 2.7.

μ_1--the linear attenuation coefficient of the crack components.

Δx--the path the rays take in passing through the defect.

Obviously, in order to obtain an image of the cracks on the photographs, there must be a certain difference between rays I_1 and I_2 on the exposed film. The greater the difference between I_2 and I_1, the greater the detection of defects. Because the three defects shown in Figure 1 have an identical μ_1, I_2/I_1 will be determined by Δx. The Δx of the three defects can be seen easily in Figure 1. They are a > b > c. Crack c, which runs perpendicular to the rays is the hardest to see.



(a) (b) (c)

Figure 1. The Effects of Crack Direction

II. Effects of Focal Length on Crack Visibility

Although transverse cracks in spherical vessel welding seams have the characteristic of radiating toward the center and have a direction similar to crack a in Figure 1, radiographic inspection of welding seams requires that a certain line source be used inside with the film placed outside because of the beam emission actually used. Moreover, the focal length will not necessarily be the same as the radius of the spherical vessel. For this reason, with the exception of the center rays of the beam, the remaining rays will form a certain transillumination angle α when they strike a transverse crack. This causes Δx to become smaller and affects the results of the inspection.

We now will use a spherical vessel with a volume of 400 m^3 and a radius of 4,570 mm to illustrate the relationship between changes in focal length and the transillumination angle when using radiographic methods.

1. Transillumination with the line source on the inside and the film on the outside can be used (Figure 2). When the line is of a given length, if the line source (the focal point of the radiography machine) is placed at the center of the spherical vessel, then all of the beams will have a transillumination angle α of 0°. If the line source is moved from the center of the sphere to its periphery, which reduces the focal length, the transillumination angle α obviously will become greater with a reduction in the focal length and an increase in the beam emission angle ϕ. At this time, the transillumination angle α of the rays can be derived from the radius of the spherical vessel R + δ (OB) and the distance between the line source and center of the sphere, which is the difference F between the radius and the focal point + δ (OA), and ϕ:

$$\sin\alpha = \frac{[R-(F-\delta)]\sin\phi}{R+\delta} \qquad (2)$$

In the formula, δ = the wall thickness of the spherical vessel (in mm).

For example, when transillumination of the above spherical vessel uses a focal length of 600 mm, the angle of divergence β is 5° and the transillumination angle α of the rays at the end of the film is:

$$\sin\alpha = \frac{[4570-(600-32)] \times 0.0872}{4570+32} = 0.0758$$

$$\alpha = 4.34°$$

If the focal length is reduced to 300 mm, then the angle of divergence of the beam changes to 10°, while the transillumination angle α at the end of the film is about 9.3°.

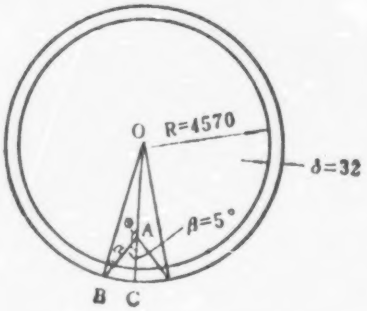
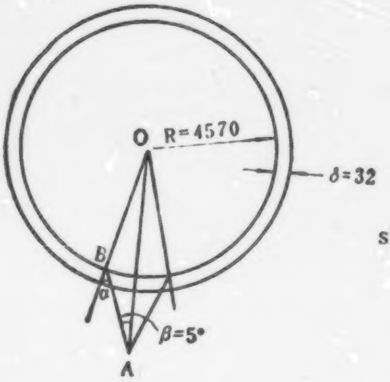


Figure 2. Illustration of the Derivation of Focal Length and Transillumination Angle During Transillumination With the Line Source on the Inside and Film on the Outside

2. Transillumination with the line source on the outside and the film on the inside can be used (Figure 3). When the length of the film is given, there will be a certain transillumination angle regardless of the focal length. Like transillumination with the line source on the inside and the film on the outside, there is a regularity in which the angle of beam divergence becomes greater and the transillumination angle of the rays at the end of the film increases as the focal length becomes smaller. Based on the known beam divergence angle β, the focal length F, the radius of the spherical vessel R and other values, the law of sines for an arbitrary triangle can be applied to derive the transillumination angle α of the rays at the end of the film.



$$\sin\alpha = \frac{(R+F)\sin\beta}{R}$$

Figure 3. Illustration of the Derivation of Focal Length and Transillumination Angle During Transillumination With the Line Source on the Outside and Film on the Inside

For example, when a 600 mm focal length is used for transillumination of the spherical vessel described previously, if the divergence angle β is 5° the transillumination angle α of the rays at the end of the film is 5.6°. If the focal length is reduced to 300 mm, the beam divergence angle β becomes 10°, while the transillumination angle α of the rays at the end of the film is about 10.7°.

We can see from the above that under identical focal length and beam divergence angle conditions, the transillumination angle for transillumination with the line source outside must be greater than that of transillumination with the line source on the inside.

III. Effects of Film Length on Crack Visibility

If there is a set focal length when doing radiographic inspection of welding seams in spherical vessels but different lengths of film are used, then the beam divergence angle will have the following relation to them:

$$\beta = \frac{L/2}{0.01745F} \qquad (3)$$

For this reason, a greater film length L leads to a greater beam divergence angle β and a greater transillumination angle α of the rays at the end of the film. Table 1 shows the relationship between film length and beam divergence angle when using a focal length of 600 mm with a 400 m^3 spherical vessel. The first part of the British B.S2600 standards stipulate that the following film length L should be adopted when using an exterior line source for transillumination of welding seams in spherical vessels:

$$L=0.017D\left[\cos^{-1}\frac{1}{1.06}-\sin^{-1}\left(\frac{D}{D+2F}\sin\cos^{-1}\frac{1}{1.06}\right)\right] \qquad (4)$$

Here, D is the diameter of the spherical vessel, while 1.06 is the transillumination/thickness ratio, which is δ_{max}/δ. F is the focal distance. For the spherical vessel described above, when the focal length is 600 mm then the film length L that should be adopted according to formula 4 is 362 mm. The beam divergence angle at this time is 17.3°, while the transillumination angle is about 19°.

It is quite obvious that a greater film length also can increase the distance between the crack and the center of the film and can make visibility even poorer.

Table 1. Beam Value With Different Film Lengths in a 400 m^3 Spherical Vessel Using 600 mm F Transillumination

Film length (mm)	20.9	104.7	125.6	146.6	167.5	188.5	209.4	230.2	251
Beam divergence angle (deg)	1	5	6	7	8	9	10	11	12

IV. Effects of Crack Depth on Visibility

The effects of crack depth and distance from the transilluminated surface can be analyzed using the principle of geometric non-resolution for the images formed.

As everyone knows, geometric non-resolution is determined by the focal point of the line source, by the distance between the focal point and the defect and by the distance between the defect and the film. When the focal point measurement and the distance between the defect and the focal point is given, a greater distance between defect and film will cause greater geometric non-resolution in the image of the defect. This means that shallower defects are more difficult to detect.

Nevertheless, for spherical vessels with a wall thickness that is not too great, the crack depth usually has only small effects on visibility. Only when the wall thickness is greater than 40 mm does the effects of crack depth become apparent. Such effects are much smaller than those caused by the transillumination angle.

V. Effects of Ray Energy on Crack Visibility

The linear attenuation coefficient μ of the transilluminated material is related to the ray energy. It is easy to see from formula 1b that in order to increase I_2/I_1 and to increase the density differential of the defect and test item image on the photograph, then at a certain Δx, low voltage obviously should be adopted to improve the linear attenuation coefficient μ.

In another area, increases in ray energy cause a reduction in the linear attenuation coefficient, which can cause a corresponding decrease in the ratio I_1/I_0, which will reduce ΔD, the density differential of the image of the defect. As ray energy is increased, the degree of weakening in the ray intensity differential at the film is called the scattering ratio n. When other factors are ignored, there is a direct proportional relationship between ΔD and $\mu/(1+n)$. For this reason, when considering the improvement of crack image comparison caused by increasing ΔD, the tube voltage used during transillumination of the spherical vessel should not be too high.

VI. Conclusions

The following conclusions concerning the use of radiography for this type of transverse cracks in welding seams can be drawn based on the above analysis and proof through practice.

1. When the transillumination angle of the rays striking the cracks is >15°, they cannot be detected. When the transillumination angle is 13°, it is rather difficult to detect the cracks. For this reason, it is best if the transillumination angle is no greater than 11°.

2. Transillumination of a 400 m^3 spherical vessel with 32 mm thick walls is limited only by equipment capacity and the desire to improve the speed of inspection. Although the requirements of geometric non-resolution are met when the focal length is 600 mm, the need to assure that the transillumination angle is no greater than 11° as mentioned above means that a rather short film should be used (usually with an effective length of 240 mm). This will reduce the area of transillumination, so determination of whether or not formula 4 is appropriate awaits study.

3. The greater number of cracks on the inner walls means that we should begin with improvement of the geometric resolution of the rays and adopt transillumination with the line source on the exterior and the film on the interior. Because the transillumination angle derived in this manner under identical focal lengths is greater than in a situation with the line source on the interior and the film on the exterior, which aids in detection of transverse cracks, transillumination with the line source on the exterior still is the most suitable.

4. Although in theory one should strive to use a rather low tube voltage if it is capable of penetration, the increased internal scattering of the rays in the low voltage tube makes it hard to ignore the fact that the longer exposure and other factors reduce ΔD. The disadvantages of both methods should be weighed to select the most appropriate one. The tube voltage used for the spherical vessel described above generally was not less than 200 KVP.

5. The above discussion is predicated on the cracks having a certain thickness and that Δx is $\geq$ the transillumination sensitivity. Real cracks, however, sometimes are less than 0.1 mm wide. This makes them difficult to detect when they run parallel with the direction of the rays, which means that the use of radiographic methods for crack detection is greatly limited. For this reason, inspection of welding seams in spherical vessels should adopt ultrasound, magnetic powder, staining and other measures for comprehensive defect detection in order to reduce the non-detection of cracks.

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CHINA'S URANIUM RESOURCES APPRAISED

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[Article by Wang Jian [3769 7002]]

[Excerpts] A nation's energy policy and its decision-making process of developing strategic and tactical nuclear weapons and the nuclear industry are determined by the quantity and economic values of its uranium resources. Uranium resources affect many aspects of the relationships between nations: politics, economy, trade, and science and technology. The radioactive property of uranium also affects human beings both physiologically and psychologically. For this reason, uranium is a very sensitive strategic material and the development and appraisal of a nation's uranium resources is a very important task. The purpose of appraisal is to determine the quantity and quality of resources and the feasibility and economics of developing the resources. To obtain an objective assessment of uranium resources and to develop practical guidelines and policies for the nuclear industry requires scientific appraisal methods.

Socialist production is the production of commercial goods under planned direction. The production of commercial goods must be concerned with not only utility values but also commercial values, or economic payoff. The production of uranium is no exception. The formation of uranium deposits follow certain pattern, but there are considerable differences in regional distribution, depth of ore deposits, the quantity of reserves, the size and shape of the deposits, and the degree of difficulty in mining and processing. The natural deposit of uranium resources can be estimated by using existing knowledge in geology and engineering techniques, but the degree of confidence in the estimate increases with geological exploration and actual production. The so-called "reliability of estimated reserve" refers to the degree of understanding about the ore deposit. In simple terms, the appraisal of uranium resources is to use scientific methods to appraise the economics and reliability of the uranium resources. Uranium resources can be classified according to the economic payoff of developed uranium mines and the degree of geological exploration; this information can be used as a basis for establishing policies and plans for developing the nuclear industry.

Uranium is a non-renewable natural material. Therefore, the appraisal process must take into consideration the efficient use of this valuable resource in order to minimize loss and waste.

Appraisal of uranium resources involves the following factors:

1. Condition of geological deposit of the resource. The size and quantity of the ore deposit, the spatial position, the uranium concentration, the continuity of mineralization, the properties and structure of earth stratum, and the physical and chemical properties of the surrounding rocks and ore directly affect the depth of exploration, the techniques of mining and processing, and cost.

2. Economics of resource development. The ratio of funds invested in developing the resources and the funds generated by the products is a measure of economic payoff. The factors which affect economic payoff include the grade of the ore deposit, the mining depletion rate, the cost of mining, processing and transportation, the rate of recovery, and the sale price of the product. Of these factors the most sensitive is the ore grade, which can vary from several hundredth of a percent to several percent; in some cases the ore bed itself may vary a great deal in richness. Clearly, an ore bed is economically profitable if the income from the sales is higher than the production cost. In recent years, the price of natural uranium has been dropping drastically on the international market. Many factories and mining operations in the United States and Canada have closed down because of lack of profitability.

3. Technical conditions for mining and hydrometallurgical processing. Because of different deposit conditions, some ore deposits are easy to mine and process, thus production cost is low; some may be easy to mine and process, but the recovery rate is low, hence its economic payoff is poor; others are still unminable or unprocessable using current technology.

4. Political factors. The defense policy, energy policy, foreign policy and trade policy of a nation directly affect the demand, production, and volume of import/export, and the price of uranium resources and uranium products; as a result, they also affect the appraisal of uranium resources.

5. Time factor. With the continuing exploration and development of uranium ores, the quantity and spatial distribution of uranium resources change accordingly. Also, the sale price, production cost, mining and processing techniques, and political atmosphere change with time. Therefore, resource appraisal is a function of time and must be performed periodically.

Countries with uranium resources and nuclear energy organizations devote a significant amount of effort to uranium appraisal. They not only conduct appraisals of their domestic resources but also monitor the uranium appraisals of other countries in order to adjust their own nuclear policies. In the appraisal process, they classify the uranium resources according to their reliability and economics. They also devote considerable amount of research effort to improve the method of appraisal and the method of calculating uranium reserves. During the 12th International Mining

Conference held in New Delhi in 1984, many papers were concerned with the topic of resource appraisal, which illustrates one aspect of the development trend of current technology. We shall now present a few examples of the classification of uranium resources by several countries and organizations.

In geological exploration, it is common practice to use the authorized cost indices for uranium products to calculate the marginal grade of each ore bed and to estimate the uranium reserve according to the ore deposits and the technical conditions of mining and processing. Different marginal grades and industrial indices are used for different ore beds. In resource classification, the best category in terms of economics and reliability is called industrial reserve. It is used for establishing development plans for nuclear energy and for coordinating the fuel requirement during the operating life of nuclear reactors (typically 30 years); it is also used as a basis for establishing guidelines for import and export of uranium products. The categories other than industrial reserve are simply called backup resources; they cannot be used for establishing plans of nuclear energy development. The IAEA generally conducts an appraisal of each country's uranium resources every 2 years. Since 1975, this organization has used "cost" instead of "price" as a basis for appraising uranium resources. Most countries use the "cost" method of appraisal, but Canada still uses the "price" method. Canada has established a Uranium Resource Appraisal Group (URAG) whose members consist of government officials and experts in geology, mining and hydrometallurgy. The group has three branches: 1) The assured resource branch, which is responsible for the authorization of "assured reserve" and calculated reserve, and for estimating the uranium production level based on these reserves; 2) The estimated additional resource branch, which is responsible for the estimation of additional resource, including evaluation of the "predicted resource," and 3) The economic coordination branch, which is responsible for coordinating domestic uranium needs and uranium export, and for determining the uranium reserve required for domestic reactor operation.

The terminologies used by different countries for classifying uranium resources are quite similar.

Many countries are using new technologies, new procedures, and new methods to improve the utilization of uranium resources and to reduce production cost. Radioactive mine selection and immersion mining techniques have been used extensively in extracting low quality level ores, so that some resources have been converted into reserve. By using geological statistical methods to calculate uranium reserve and to guide exploration, the effectiveness of exploration and the reliability of estimated reserve are improved and the quality of resource appraisal is upgraded.

The 30 years of geological exploration since China's liberation have produced considerable amount of uranium resources and have made significant contributions to the development of China's nuclear industry. During the 50's, it was necessary to use the then Soviet theory and method of geological exploration and industrial indices in order to find uranium ore as quickly as possible to meet the military and industrial needs.

During this initial stage of production, emphasis was placed on the effectiveness of exploration; little attention was given to the economics of resource development, and resource appraisal was non-existent. When the nuclear industry has evolved to the stage of "serving the people while meeting military needs," we must be concerned with the economic payoff in nuclear power generation, and we should promote the appraisal of China's uranium resources.

To begin this new era of uranium resource appraisal, we must take a very practical approach. Here are some suggestions:

1. Preparation for uranium appraisal. We suggest that a special appraisal group be organized by the Radioactive Mineral Special Committee to be solely responsible for the appraisal of uranium resources; members of this group will include experts in geology, mining, hydrometallurgy, and technical economics. The group will be tasked to develop the basic concepts and guidelines for appraisal of China's uranium resources, to specify the classifications and standards of uranium resources based on economic payoff and reliability, and to define the necessary technical/economic indices as well as appraisal theories and methods; they will also be tasked to publish an "Appraisal Standards" which will be used in appraisal work after being submitted for approval.

2. Appraisal of uranium resources which have already been submitted. For those reserves which have been submitted and approved by the reserve commission, the original industrial indices and reserves can be used to estimate the production cost and to determine the classification of each ore bed according to the "Appraisal Standards." The reserve which has been depleted and written off will not be appraised. The ore beds which are under construction will be appraised and classified according to the assessed initial deposit and the degree of development. Ore beds which have not been constructed will be appraised and classified according to the approved reserve. Resources which have not been approved by the reserve commission must first be approved before appraisal.

The appraisal of each ore bed requires estimating the amount of recoverable uranium and the cost of producing 1 ton of natural uranium. Based on China's current production level, the cost of producing 1 ton of uranium can be divided into 10 50,000-yuan segments between 0 and 500,000 yuan. By determining the cumulative number of resources in the same cost segment, an uranium cost curve can be constructed. Also, based on the current production level, a profit-loss curve of China's uranium mines can be generated (e.g., assuming the cost of uranium per ton to be 220,000 yuan, based on 80 U.S. dollar per kg). The projection of the point of intersection between the cost curve and the profit-loss curve, A, is the cumulative uranium resource that may produce a profit. Thus the resource between A and O is economical resource. The resource between A and B is sub-economical resource, whose cost may be lowered to the break-even point on the profit-loss curve through improved technologies and management. The resource beyond the point B is uneconomical resource, which will not be considered for development within 20 years.

3. Appraisal of newly explored resources. For future exploration of uranium ores, the original indices used by the Third Five-Year Plan are no longer applicable; new industrial indices based on current conditions must be specified for general search and exploration. After initial exploration is completed, the geological, mining and processing conditions of a particular ore bed should be examined to determine the most appropriate industrial indices to be used for guiding detailed exploration, calculating reserve for the final geological report, and for resource appraisal and ore development. For those resources which are technically not feasible, economically non-profitable, or are not recommended for development within an extended period, detailed exploration will not be initiated in order to avoid premature commitment of valuable funds.

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APPLIED SCIENCES

DRY VACUUM DISTILLATION DISCUSSED

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[Text] In recent years, China's annual crude oil output has approached about 100 million tons. Of this, the yields of straight-run gasoline, kerosene and diesel oil depend on the crude but generally total 25-30 percent of the crude oil. By vacuum distillation of the remaining atmospheric heavy oil, another 20-30 percent distillates are obtained and used as basic stocks for: lubricating oils and paraffin wax; catalytic preparation of gasoline and diesel oil; and the production of petrochemical feedstocks by pyrolytic cracking. To avoid the decomposition at high temperature of heavy oil inside heating furnace and pressure reducing tower, which would affect the quality of distillate oils, superheated steam is injected into furnace coils and tower. The traditional wet vacuum distillation tower operates under 50-150 mm Hg in the flash zone. Recently, dry vacuum distillation, which is operated at higher vacuum and without steam injection, has been developed both in China and abroad. It can be used to improve the yields of gasoline and diesel oil as well as to increase the production of petrochemical feedstocks.[1] If this method is widely adopted in China, oil refining alone could result in increased production with an economic benefit of over 600 million yuan.

I. Advantages of Dry Vacuum Distillation

The advantages of dry vacuum distillation over traditional wet vacuum distillation, as determined from practical experience, are:

1. Improved Distillation Yield of Desired Products. The increase of distillation yield is 2-5 percent of the feed or 1.4-3.6 percent of the crude. In recent years, we have processed over 70 million tons of crude. If wet vacuum distillation is totally replaced by dry vacuum distillation, additional amounts of distillate oils can be further cracked catalytically to yield about 1.225 million tons more of gasoline and diesel oil, and equivalent to an increase in output value of over 500 million yuan. The economic benefit would be even more substantial if they are converted into petrochemical products.

2. Energy Savings. Because there is no steam injection into heating furnace coils and decompression tower, the total amount of steam in the decompression system can be reduced by 50-70 percent. The cooling load of the decompression system for refineries with an annual processing capacity of 3 million tons of crude can be reduced by 3 million kcal/hr, which results in tremendous savings in heating fuels. The energy consumption for atmospheric and decompression installations are reduced from 223,900 kcal/ton of crude to 132,200 kcal/ton of crude. If 70 million tons of crude is processed in China, the saving in fuel oil can be 641,900 tons, which is valued at 86.015 million yuan.

3. Improved Tower Capacity. When metal stacking ring packing is used, the capacity of a dry decompression tower can be raised by about 30 percent while pressure drop through the tower can be reduced by about 50 percent. Or for the same capacity of 1.32 million ton/year, the diameter of the decompression tower can be reduced from 8.34 meters to 5.79.

4. Small Pressure Drop, Good Heat Transfer, Large Operational Flexibility and Certain Degree of Fractionation. The pressure drop of the dry decompression tower with the new type of packing is only 1/3-1/5 that of the plate tower. The cross-sectional production capacity of the tower for wax oil ranges from 25,400 to 45,000 ton/year·m^2. Over 1,000 units of dry decompression tower are being used abroad mainly for absorption, stripping and distillation.

II. Operation and Design Principle of Dry Vacuum Distillation System

Under the prerequisite of assuring the quality of distillate oils, the specific measures to raise yield, and to lower energy consumption, production cost and initial investments as well as to raise operational flexibility are as follows:

1. Decompression Heating Furnace

Without causing thermal cracking of oil feed, the furnace outlet temperature can be higher in order to increase the yield of distillate oil. When the feed is the mixed crude of the Shengli oilfield, the furnace outlet temperature should be kept below 393°C. When oil feed is low, temperature can be lowered to save fuel.

2. Transfer Line Between Furnace Outlet and Tower

Slow speed transfer lines are generally used. Distillate oils are completely vaporized inside the section of straight tube extending 15 meters before the tower and enter the tower at the velocity of 42-54.86 m/sec. The slow speed sections of the line are supported with soft and elastic supports to avoid vibration. The flow velocity in other parts of the transfer line is 120 m/sec to allow the evaporation rate of the feed inside the furnace and transfer line to reach 90 percent or more of the overall evaporation rate. This way, the carry-over of the condensate within the transfer line into the tower can be avoided so that the contents of residual carbons and heavy metals in side-draws at the bottom of the decompression tower are sure to meet specifications. The pressure drop inside the transfer line is 90-250 mm Hg, the temperature drop is 5.6-14°C and the temperature drop between the tower inlet and the flash zone is 7-8°C. The bending stresses are largest at the transient section between the furnace outlet pipe and the slow flow section as well as the junctions between slow flow sections where vibration occurs due to gas expansion. Totally flexible supports should be used at these places and rolling brackets are installed between the support and the line. This line is connected to the decompression tower with a grade of 0.003. Reinforcing plate is welded at the joint of the two lines. Bumper plates are welded at the bottom of the slow flow line and baffling measures should be adopted after the feed enters the tower.

3. Dry Decompression Tower

The feed enters into a flash zone above the residuum section at the bottom of the tower. On top of the feed section are the washing section and the condensing zone in ascending order.

(1) Flash zone. The pressure of 15-30 mm Hg (absolute pressure) at this zone is appropriate for the primary equilibrium flash separation of gas and liquid phases. The design condition for the evaporation temperature is a junction of the properties of feed oil and the required distillation yield, and is greatly affected by the flash zone pressure. When all other factors remain constant, for every 10°C increase in flash zone temperature, the distillation yield can be raised by 2.3-4 percent (weight) or, for a 10 mm Hg decrease in pressure, the wax oil yield increases by 1-5 percent (weight). Under the condition of constant capacity and distillation yield, when flash zone temperature drops from 381°C to 360°C, then flash zone pressure should drop from 73 mm Hg to 27 mm Hg (absolute pressure). The overhead pressure drops correspondingly from 70 mm to 10 mm (absolute pressure) and pressure drop through the tower rises from 3 mm Hg to 17 mm Hg. The fuel consumption of heating furnace decreases by 19,200 kcal/ton of feed but the energy consumption of the vacuum system increases. The overall energy consumption decreases by 8,100 kcal/ton of feed. With 70 million tons of crude processed nationally, then the annual savings in fuel oil is 100,000 tons (assuming furnace efficiency of 81 percent). Therefore, there is significant economic benefit in reasonable design and manipulation of flash zone temperature, pressure and distillation yield.

(2) Washing section. It washes away the majority of heavy metals and residual-carbon entrained in the ascending vapor and thus guarantees the quality of distillate oils. It also reduces overflash and saves energy. The excess overflash oils are either returned to residuum or blended with fuel oils. The overflash is 2-3 percent of the feed. The minimum spray density of wash-oil is 1 $m^3/m^2 \cdot h$. To assure the quality of distillate oils, the amount of wash-oil cannot be reduced even when the load decreases.

(3) Condensation zone. Here the ascending product oils are condensed and drawn into collecting boxes. This is mainly done by primary equilibrium condensation. Packed sections or trays work as long as there is enough heat

exchange area. The collecting boxes isolate each side-stream into independent section. There is no inner reflux passing between them. Because of the condensation, the volume of gas at the bottom of a packed section is 5-10 times that at the top.

(4) Side-streams of the tower. The number of side-streams should be based on the overall consideration of investment, heat recovery, feed load, number of mechanical pumps, length of line, size of lot and operation management. One side-stream is chosen when the feed load is less than half million tons/year; two side-streams when the fuel exceeds 1 million tons/year. Currently, several dry vacuum towers for the feed load of 30,000-100,000 tons/year are in the design stage. But the number of side-streams is being examined adequately. The situation should be corrected.

(5) Feed and reflux heat distribution for each side-stream. More head can be recovered when using two side-streams. The ratios for feed distribution and reflex heat distribution of the two side-streams are best under 40:60 and 20:80, respectively.

(6) Overhead temperature. When overhead temperature is 90-100°C, the amount of topped oil is more than 1 percent of the feed oil and is almost nonexistent at 45°C. The temperature of the topped oil is set at 60-80°C, which is 15-20°C higher than the top reflux temperature.

(7) Tower bottom temperature. It should be designed to be 1-3°C lower than the flash zone temperature.

(8) Reflux temperature difference. The designed approach temperature difference (the difference between the reflux temperature and the temperature of the vapor phase leaving the zone) should be no less than 30°C. The reflux temperature difference (the temperature difference between the returned and draw-off of the reflux oil) should be 80-100°C.

(9) Heat loss from the tower. The heat loss of the tower is 5 percent when the diameter of the tower is larger than 5 meters and is about 8-10 percent when smaller than 4 meters.

(10) Basic components of gas-liquid phase contact. The rectifying section of the tower is also the condensing section. The main function of tray or packing is heat transfer rather than mass transfer. To get a higher yield from the flash zone at constant temperature, the metal packing with slow flow resistance should be chosen. Considering investment, those dry decompression towers with new model vertical sieve trays[2] or combined gasketed tray and packing should be chosen. The combination type is five times cheaper than the all-packing type. Useful packings are the Interlex packing that allows large flux and small pressure drop and the Glitsch grid-stabilizing ring combination bed packing that is remarkably effective with regard to reducing tower diameter, saving investment, increasing feed load and reducing pressure drop. The Glitsch grid packing can be used for a large diameter wash zone; and the stacking ring or Interlex packing combination bed can be used for the heavy vacuum gas oil zone. Their height ratio is 1:2. The random

packing is best suitable for the light vacuum gas oil packing zone. The packing glands and bolted nuts should be used inside the tower in order to keep nuts from becoming loose under repeated poundings. When packings are loaded for the first time, they should be sprayed with water to settle before glands can be installed.

(11) The diameter of the tower at packing layer.[3] When processing a constant amount of feed, the tower diameter at the packing layer is influenced by the type of packing. The equation is as follows:

$$D=\sqrt{\frac{\theta_V}{0.785\times 3600\omega}}=0.0188\sqrt{\frac{\theta_V}{\omega}}\ [m] \quad (1)$$

$$\omega=\frac{C}{\sqrt{\frac{\rho_g}{\rho_L-\rho_g}}} \quad [m/sec] \quad (2)$$

where: D--tower diameter [m], θ_V--gas phase flow rate inside the tower [m^3/h], ω--flow velocity with tower empty [m/sec], ρ_g--gas phase density [kg/m^3], ρ_L--liquid phase density [kg/m^3], C--packing volumetric factor [m/sec].

In general, the maximum capacity of dry vacuum distillation tower is the production of 31,000-41,300 tons/year of crude diesel oil per square meter of tower cross-section.

(12) Packing height.[3] It is related to gas phase flow velocity, liquid phase load, approach temperature difference, existing water vapor and non-condensable gas.

$$\text{Packing height } H=\frac{Q}{K\cdot\Delta t\cdot F} \quad [m] \quad (3)$$

where: Δt--logarithmic average approach temperature difference [°C], Q--heat load of sectional packing [kcal/h], K--heat transfer coefficient [$kcal/m^3\cdot h\cdot °C$], F--cross-section of tower [m^2].

The K values for ϕ50 stacking ring and 50# Interlex are described by:

$$K=1363C^{0.286}L^{0.762} \quad [kcal/m^3\cdot h\cdot °C] \quad (4)$$

where: C--average volumetric factor of packing [m/sec], L--average liquid phase load [$m^3/m^2\cdot h$].

For the overhead volumetric heat transfer of packing, the numbers of 180,000-250,000 $kcal/m^3\cdot h$ are used and, for the packing height of wash zone, 1-1.3 meters are used.

(13) Draw trays. They store and retain liquids for 2-3 minutes. Concentric round holes are placed on the inner core of draw trays for the passage of ascending vapor, whose velocity is controlled at under 10 m/sec. Hole ratio

of 30 percent is good. There are no orifices on the bottom plate of the tray and outlet is placed beneath the bottom plate. At the end of operation, collected liquid is emptied into draw-off system. The quality and mode of weldings between the bottom plate and tower wall should be such that they will not crack under high and low temperatures. After the completion of this job, the quality of weldings should be checked by filling trays with water and let sit for 24 hours. Because of the high viscosity of oils, the ball float liquid level indicators are used in draw trays. When coupled with the regulating valve on the product draw-off line, the liquid level inside draw tray can be automatically controlled. An 800 mm space for uniform distribution of vapor should be maintained between the top of the draw tray and the support plate for "camel's hump" packing above it. Manhole is not necessary for draw trays. If floating ball drops out of its place, it can be retrieved from the opening of ball float liquid level indicator (whose diameter is 250 mm).

(14) Tower height. Manholes should be properly positioned based on the ease of installation and maintenance. The height of liquid storage funnel at the bottom of the tower should be such that the residence time of oil feed is 3-5 minutes. To reduce mists and foams entrained in the ascending vapors, which would affect the contents of heavy metals and residual carbons in the product petrolatum oil, the distance from the center of feed inlet to the bottom of draw trays at the upper part of the tower is determined according to the equation $A = 0.2D + 1.2$ [m] and the distance from the center of inlet to the cross-section of bottom head, $B = 0.2D$ [m] (D is the tower diameter in meters). The individual draw tray height is 0.35 meter. It is better to equally space draw tray, grid packing and ejector head by 0.45 meter.

(15) Liquid distributor. It is an important factor in determining the packing efficiency on liquid. The liquid distribution is good when the liquid pressure is maintained at 1-3 kg/cm^2 and forked tongues are 90° from one another on the spinning ejector head. The ejector head of 1Cr18Ni9Ti is recommended for the crude from Shengli oilfield and other corrosive oils. Sixty mesh filter should be installed before the ejector head. The performance of ejector head can be checked with water instead of oil with negligible error.

(16) Distribution cone. It keeps liquid from being sprayed onto tower wall that will cause undesirable wall effect. It is made by rolling a piece of 60 mm wide thin steel. These cones are positioned 150-200 mm above the surface of packings and welded to tower wall at 45° angle.

4. Evacuation System

When the residual overhead pressure is 11 mm Hg and compression ratio of pressure booster is 7, the exhausting device is operable with 16 kg of saturated steam at a pressure of 9 kg/cm^2, per ton of crude. This is a saving of about 7.7 kg of saturated steam per ton of crude over wet vacuum distillation. The suction vapor load of exhausting device is reduced by 80-90 percent over wet vacuum distillation. When processing the mixed crude of Shengli oilfield, the amount of noncondensables is 0.08 percent of vacuum feed while overhead condensables is 0.2-0.48 percent. The steam ejector should be placed horizontally or vertically but never upside-down. Pressure booster should be positioned near the overhead to minimize the length of pipe and resistance from the overhead to pressure booster. Energy savings have been achieved by using mechanical vacuum pumps or vacuum devices that are coupled with steam ejectors.[4] The gas outlet of cooling condenser should be placed on the outlet pipe at the lower section to prevent vapor from taking shortcuts through the orifices on baffles. The last stage condenser can be installed on the platform at the bottom.

In summary, replacing wet vacuum distillation with dry vacuum distillation not only can improve yield but also save energy and provide good operational flexibility. It is one of the good measures for realizing the four modernizations in oil refining and the chemical industry.

Note: The assistance and guidance of Zhang Youshi [1728 0645 4258], chief engineer at Jinling Petrochemical Corp., Qiu Guoqi [6726 0948 0892], director of Loyang Research Plant of [Jinling] Petrochemical Corp., Zhu Renyi [2612 0086 5030], chief engineer at Shanghai Gaoqiao Petrochemical Corp., Sun Bairen [1327 4102 1804], deputy director of Wuxi Chemical Industry Bureau, Jiang Hu [1203 3338], Wu Xiangchen [0702 3275 5256], and Ji Gang [1323 6921], engineers at Wuxi Resin Plant, are acknowledged.

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ENVIRONMENTAL QUALITY

DISPOSAL OF RADIOACTIVE WASTE FROM PWR REACTOR

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[Article by Tang Zongyan [0781 1350 3508], Science and Technology Information Institute, Ministry of Water Resources and Electric Power: "PWR Nuclear Power Stations: Handling of Radioactive Wastes From a PWR Reactor and Impact of Radioactive Discharge on the Environment"]

[Text] I. Handling of Radioactive Wastes

The fuel uranium used in PWR is uranium ore which is extracted from underground and which, after a complex process of sorting, refining, chemical conversion, enriching, and processing, is manufactured into fuel elements. This processing of nuclear fuel before placing it in the reactor is generally termed "preprocessing." After "burning" in the reactor, the uranium fuel should be "postprocessed" to recover uranium which has not been fully consumed and the plutonium which is produced and also to extract some fission products and transuranium elements. The entire process from extraction of the uranium ore to the recovery of radioactive nuclear elements in the spent fuel is called "fuel recycling." Radioactive wastes are produced at each stage. This paper is a brief introduction to the handling of radioactive wastes produced only in the operation process of a PWR power plant.

The large quantity of radioactive material produced by nuclear fission in the operation of a nuclear power station is the main source of a nuclear power plant's radioactivity. Neutron capture reactions also form a certain quantity of transuranium elements and activated products of the structural materials. When the fuel element casing is damaged, some fission products can enter the coolant. After the structural part of the reactor has undergone corrosion or damage, activated products of the structural materials also can enter the coolant. In addition, when impurities in the coolant pass the reactor core, they can also become radioactive due to neutron radiation.

It is necessary strictly to collect, handle and control radioactive wastes produced during operations in the nuclear power plant to prevent radioactive materials which exceed the maximum allowable concentration from being discharged into the surrounding environment. For this reason, radioactive waste collection and handling systems have been established.

1. Source and Handling of Radioactive Gases

Below we explain the source and handling methods of the waste gases produced during ordinary operations.

(1) Exhaust gases from volume control tanks and other equipment

The gases used in a circuit of a PWR nuclear power plant include hydrogen gas, which is added to the coolant to inhibit corrosion, and nitrogen gas, which is used as a cover gas in the water tanks. The hydrogen is added to the volume control tanks to maintain the hydrogen concentration in the coolant. In the gas in the volume control tanks and the water tanks, the hydrogen or nitrogen mix with the radioactive gases given off by the reactor coolant. Thus the gas which is replaced and expelled in the volume control tank during starting and stopping the reactor and the cover gas which is expelled as the water level rises in the water tanks during operation both are waste gases which are radioactive. In addition, gases are expelled when the boron recovery equipment is operating. These gases are stored in the gas decay tank for a certain period of time so that the short-life krypton, xenon, and iodine isotopes in the waste gas drops more than 99.9 percent, then they are either expelled or reused, depending on the strength of the radioactivity and composition of the gas.

Recently, hydrogen recombination or separation devices have been installed in some PWR power plants. The hydrogen recombination device is made up of a preheater, catalytic reactor, cooler and water separator. The waste gases containing hydrogen which are expelled from the gas space in the volume control tank are forced into the catalytic converter by the waste gas compressor and with the introduction of appropriate amounts of oxygen and the reaction with the surface of the catalyst turns it into water and steam which thus reduces the concentration of hydrogen. The water in the gas mixture is eliminated through the cooler and the water separator. The remaining gas is transported from the recombination device to the hydrogen recombined gas decay tank and then returned to the compressor inlet where it completes the cycle. Within the cycle, after the remaining concentration of hydrogen bearing waste gas has reached a low level, it is sent to the waste gas decay tank.

The exhaust gases of these devices go through exhaust gas collector tubes and are sent by the waste gas compressor to the gas decay tank for storage. For example, when the coolant is drawn off to adjust the iodine concentration and due to heat expansion in the cooling system is sent to the holding tank, the waste gases expelled in the gas space of the holding tank enters the exhaust gas collection tube as waste gas.

If the radioactive gas stored in the gas decay tank is largely nitrogen and the oxygen concentration in the gas is below the limit, this gas can be reused as a cover gas in the holding tank; if it exceeds the limit, then it is held for a certain period of time before discharge.

(2) Reactor safety shell ventilation

If the cycling coolant within the reactor's containment shell leaks, radioactive material will contaminate the ventilation. In addition, some of the Ar-40 in the air is converted into Ar-41 through neutron radiation around the reactor container. Therefore, when workers enter the containment shell after the reactor stops the air must be changed by containment shell ventilation and air conditioning equipment. After the air has been changed, the expelled gases first go through containment shell air cleaning equipment, and the radioactive grains and iodine eliminated from the air by particle filters and iodine filters, then it is expelled by an exhaust fan through the containment shell stack.

If the containment shell pressure rises to near a designated value during operation of the reactor, it is necessary to exhaust a small amount of air through radioactive ray control room exhaust gas filtering equipment made up of particle filters and iodine filters to reduce pressure.

(3) Reactor auxiliary building ventilation

If the cycling coolant in the reactor's auxiliary buildings leaks, some radioactive material will contaminate the air. Auxiliary room and safety auxiliary room ventilation exhaust ordinarily is expelled after the auxiliary building exhaust filter equipment (microparticle filter) eliminates radioactive microparticles. Ventilation exhaust of the waste fuel holding pool is expelled after the fuel storage exhaust filter equipment (microparticle filters) eliminates radioactive microparticles.

When any waste gas is released its concentration of radioactive matter is monitored by the gas monitor and is expelled from the stacks in diluted form.

2. Sources and Treatment of Radioactive Waste Liquids

The following types of waste liquids are produced during normal operation:

(1) Water drawn to regulate boron concentration of circulating coolant is taken to the holding tank.

(2) Coolant drain-off from the containment shell and the auxiliary buildings is taken to the containment shell coolant drain-off tank and the auxiliary buildings coolant drain-off tank.

(3) Depending on water quality, the drainage water of auxiliary building equipment is taken to the A waste fluid storage tank, B waste fluid storage tank or auxiliary building equipment shu drainage tank.

(4) The containment shell surface drainage and the auxiliary buildings surface drainage is collected in the containment shell catchment pond and the auxiliary buildings catchment pond.

(5) Chemical drainage from the chemical room is taken by the chemical drainage tank.

(6) Washing drainage, i.e., laundry drainage, washroom drainage and bathing drainage, is taken by the washing drainage tank.

There are four handling systems in the waste water handling equipment: boron recovery system, A waste water treatment system, B waste water treatment system, and washing drainage treatment system. Each type of waste water is handled by one of these systems.

Water drawn off from the circulating coolant and drainage from the containment shell and auxiliary buildings coolant is treated by the boron recovery system to separate the boric acid from pure water. This system consists of the boron recovery intake ionic exchanger, coolant storage tank, boron recovery equipment, boron ion removal exchange, boric acid concentrate tank, and monitor. After the waste liquid has been cleaned of ionized matter by the ion exchanger and stored in the coolant storage tank, the boron recovery degassing column of the boron recovery equipment separates the soluble gases (the separated gases are treated as waste gases). The soluble solid matter concentrations in the degassed coolant are separated by the evaporator in the boron recovery equipment. After going through the boron ion exchange, the condensation obtained by the evaporator is reused as recharging water for the reactor. The concentrated liquid is reused to recharge the boric acid solution. Before use it must be chemically tested to check if it conforms to reuse standards.

Water from the drainage of the auxiliary buildings equipment which is of low conductivity and high purity (A waste liquids) is treated by the A waste liquid treatment system. Waste liquid is first stored in the A waste liquid storage tank, then the soluble solid matter concentrations are separated by the waste liquid evaporation equipment. After the condensate obtained by evaporation has gone through the ion exchange to improve its purity, in principle it can be reused as recharging water. After curing, the concentrated waste liquid is treated as solid waste.

B waste liquids, containment shell and auxiliary building surface drainage in the shu drainage from auxiliary building equipment is processed by the B waste liquid treatment system. The treatment steps in the B waste liquid treatment system are similar to those in the A waste liquid treatment system. The only difference is that the condensate obtained by evaporation is not recovered, but is sent to the condensate tank through the ion exchanger, and after determining here that the radioactivity is low it is diluted with the condenser coolant and discharged through the drainage outlet. After curing by the barrel packing equipment, the concentrated waste liquid is treated as solid waste.

Laundry drainage in principle is treated by the laundry drainage treatment system. The soluble radioactive material in the waste water is separated by the laundry drainage treatment equipment, the condensate (or shentoushui

[2334 6631 3055] obtained through evaporation is sent to the laundry drainage monitoring trough and after making sure that the radioactivity is very low, it is diluted with condensate coolant and drained through the drainage outlet. The concentrated waste liquid is sent to the barrel packing equipment and treated as solid waste.

3. Sources and Treatment of Radioactive Solid Waste

Most radioactive waste produced by nuclear power stations is ultimately concentrated into solid waste. This solid waste is of medium and low radioactive level in the entire fuel cycle and after 300-500 years in storage can reach a harmless level. Most countries use land storage as the method for permanent disposal, i.e., an area which is geologically stable and has a low water table is selected for construction of a permanent waste dump collecting the solid waste of many nuclear power stations for permanent storage. Many abandoned mines, such as salt mines, limestone mines, and gypsum mines can be used as waste dumps. Many coastal countries use marine dumping as a permanent disposal method, i.e., tightly sealed solid waste is dumped into the deep sea where it is geologically and hydrologically stable. In recent years, marine dumping of radioactive wastes has come to be opposed by more and more people.

Before final disposal, solid wastes are stored in waste dumps inside the power station. The processing methods used are: curing in barrels in cement or asphalt or compacted by such methods as incineration, compression, crushing, dissolution.

The types of solid waste and the methods for solid waste treatment are as follows:

(1) The concentrated waste liquid from the waste liquid evaporation equipment and laundry drainage processing equipment is piped to the loading equipment which loads it into cement or asphalt curing barrels.

The strong acids in the chemical drainage are loaded into cement curing barrels by the loading equipment.

(2) The waste resins from the ion exchanger are piped to the waste resin tank for storage after being stored temporarily in the waste resin tank. The water used for piping is supplied by the reactor water supply tank. After the waste resins have been in the storage tank for approximately one year, have decayed to low radioactivity, they are sent to the loading equipment and loaded into barrels after the water has been extracted. The water which has been extracted can be recycled and must not be discharged.

(3) Miscellaneous solid waste, such as cloth, paper, and small tools, is generally treated by the compression method, that is, the crusher compacts crushable solid wastes into barrels to reduce bulk. Where there is incineration equipment, combustible solid waste and waste oil can be incinerated, and the ash and used and damaged ceramic filter cores packed into barrels after being crushed.

Miscellaneous solid wastes which cannot be compressed are sealed in barrels or cans depending on size and degree of contamination or measures such as binding to prevent the spread of the contamination are adopted.

(4) Used liquid filters are bound to prevent radioactive matter from scattering.

II. Impact of Radioactive Matter on the Environment

In the operation of a nuclear power plant it is unavoidable that some radioactive matter is released into the surrounding environment, just the same as thermoelectric power plants or other production processes cannot help but release some pollutants. However, nuclear power plant design can keep the radioactive discharge much lower than the degree to which they will influence the health of residents. In fact, radioactive discharge from nuclear power plants is unusually low, even to the point of being very hard to detect.

Now, nuclear power plant radioactive waste liquid discharge is limited to a level at which the residents in the surrounding area receive a dosage of no more than 3 mrem annually. Gas discharges are limited to a dosage of no more than 5 mrem received by a hypothetical man sitting on the boundary fence for 24 hours a day for a 365-day year and dosage no greater than 1 mrem received by residents in the vicinity of the power station. Compared with this dosage, the natural background radiation is 100-150 mrem (fluctuation of 20-30 mrem) annually, and the medical radiation received annually is 70-80 mrem. Thus, the increased dosage of radioactivity received by residents in the vicinity of a nuclear power plant due to the plant's radioactive discharge is less than 1 percent of the dosage they receive from natural radioactive sources. Actually, the radioactive dosage received from a nuclear power plant is less than the variation in natural background radiation. The dosage received by people who live a certain distance from a power plant should be much smaller. From this it is clear that the comparison of the environmental dosage created by nuclear power plants and the environmental dosage created by other radioactive sources with natural background radiation is insignificant.

Since 1958, nuclear power plants world-wide have accumulated over 3,000 reactor/years of operating experience, and there has never been a fatal accident caused by radioactivity. This is because in nuclear power plant design, the most harmful accident scenarios are used as the basis of design. The typical worst-case scenario is: the largest pipe which most threatens the safety of the power plant suddenly is thoroughly ruptured, and the safety safeguard systems and safety injection systems cannot function normally leading to a massive loss of coolant and the creation of a meltdown of the reactor core. The frequency of such incidents is 10^{-5}-10^{-6}/reactor year, which is unusually small.

If all the engineered safety measures to prevent such an accident fail completely and a reactor fuel element meltdown occurs, the containment shell and safety sprinkler system still can limit the range and impact of the accident's aftereffects. However, at this time the containment shell will release a certain amount of radioactive matter into the surrounding environment. At this time there are still final protective measures to safeguard the environment and the physical health of the nearby residents, and this is the plant's isolation region.

According to estimates of the U.S. Nuclear Regulatory Commission, 98 percent of the reactor core meltdowns could not cause clear human fatalities. The number of average fatalities per reactor core meltdown is 10, and the most serious reactor core meltdown (worst case-scenario) may cause 3,500 fatalities. As stated above, up to the present there has not been an accident in which release of radioactive material from a nuclear power plant has caused a fatality. But historically, personal accidents related to energy sources have always occurred. For example, in 1952, due to severe atmospheric pollution from burning coal, 3,500 persons in London died within several days, and in terms of the number of fatalities, this was equivalent to one yet-to-occur worst case scenario of a nuclear power plant.

Up to now, the biggest nuclear power plant accident in the world was the nuclear power plant accident at Three Mile Island in the U.S. on 28 March 1979. As was mentioned in the fourth lecture, the influence on human health of the radioactivity released was very small.

From the above discussion one can draw the conclusion that during normal operation of a nuclear power the radioactive dosage on the environment is minute, and the frequency of accidental radioactive discharges which endanger life safety is also extraordinarily small. Actually, the impact of nuclear power plants on the environment is much less than coal-burning power plants.

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ENVIRONMENTAL QUALITY

ACID RAIN, OTHER FACTORS STUDIED IN DESTRUCTION OF PINE FORESTS

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[Article by Yu Shuwen [0151 0647 2429] and Yu Ziwen [0205 1311 2429], Plant Physiology Institute of the Chinese Academy of Sciences, Liu Houtian [0491 0624 3944] and Shu Jianmin [5289 0313 3046], the Chinese Academy of Environmental Sciences, Ma Guangjing [7456 0342 7231], the Chinese Academy of Forestry Sciences, and Zhu Xiangyan [2612 4382 1484], Environmental Chemistry Institute of the Chinese Academy of Sciences]

[Text] In recent years, there are frequent reports of mass die-off of trees all over the country. In Sichuan alone, there are three serious cases: the Huashan pines (Pinus armandi) of Fengjie, the red pines (Pinus massoniana) of Choongqing and the firs (Abies delavayi) of Emei. In order to investigate the causes of death, the concerned state S&T Commission instructed the China Forestry Society to assemble a provisional investigation team. A team with members from the technical staff of the Chinese Academy of Sciences, Chinese Academy of Forestry Sciences, and Chinese Academy of Environmental Sciences was formed. Together with experts from the Sichuan Forestry Department, Sichuan Forestry Sciences Institute, Sichuan College of Agriculture, and the Forest Diseases and Pest Control Station of Yongchuan and Xichang, the team arrived at the locations in Sichuan in November 1984 for a 2-week investigation with emphasis on the forests of Fengjie and Chongqing.

1. The Die-offs of Fengjie's Huashan Pines

There are about 970,000 mu of Huashan pines in the Wan County area of Sichuan. Among them, 570,000 mu are damaged and 220,000 mu are dead. We chose to investigate the Maocaoba Forestry Center of Fengjie, the first to observe the die-off in this area. Within the Center, there are about 90,000 mu of pure Huashan pine forest that was artificially regenerated in 1958. Initially, the trees grew well. But now over 90 percent are dead and the surviving ones grow very poorly and are on the verge of death. The local authorities had investigated and discovered extensive disease and pest infestations. The disease was determined as premature dropping of needles caused by fungus. The pests were found to be long-horned beetles, pine beetles, and nematodes. Workers at the Center have tried standard procedures for the prevention and control of diseases and pests to no avail. Other measures such as tending, rotation lumbering, clearing out sick and dead trees and adjusting canopy density are not effective either.

The premature dropping of needles occurred sporadically in the 1960's. In 1979, a large area was infested. The symptom started with the appearance of tiny yellow spots at the base of the newly sprouted needles of that year. They then grew gradually bigger, darkening until the needles turned yellowish-brown and then dropped. The clusters of fungi spores could be seen clearly from the withered needles on the ground. Signs of pests were abundant on the trunks of dead or dying trees. Tree bark peeled off upon touch. Nematodes were detected when the trunk samples of dead, sick, and seemingly normal trees were examined by microscope. The pest infestation is still going on in the woods and destruction is inevitable. No abnormality was found when the roots were examined.

The Maocaoba Forestry Center is located in a remote mountain region, yet, surprisingly, there are many pollution sources both inside and outside the Center--small-scale sulfur plants. These plants excavate and extract sulfur from local sulfur-rich ores. Our preliminary understanding is that there are sulfur plants operated by the seven townships in this region, including over 30 clay pits. In addition, there are some small family-run plants. These plants are operated with simple equipment and primitive technology. A large proportion of the sulfur in the ores is converted into sulfur dioxide in the production process and released into the atmosphere. Using an automatic sulfur dioxide analyzer, we carried out a two-hour continuous sampling around a small plant. The highest concentration of sulfur dioxide was 2.83 mg/m^3 about 500 meters from the plant and 0.90 mg/m^3 about 1,000 meters from the plant, both far exceeding the allowed concentration. The area within 1,000 meters of the plant is completely bare with no sign of vegetation. The leaves of vegetables grown around workers' residences nearby are densely covered with greyish-white necrotic spots, typical signs of acute sulfur dioxide damage. About 2-4 li downwind from the plant, there are over 10,000 mu of dead Huashan pine. Looking from a distance, it is a patch of dark-brown. This is where the die-offs first appeared among Maocaoba's 90,000 mus of pine. The needles of individual surviving pine tree are either reddish or yellowish with the tips dried or withered, a typical symptom of sulfur dioxide damage. Furthermore, white necrotic spots appear on the pointed tips and edges of arrow bamboo leaves.

There is no local acid rain information recorded. The investigation team measured the pH of the dew formed at the tip of the pine needles. About 1,500 meters from the plant, it is generally 3.5-4.0 with the lowest reading being 3.0. This dew contains the dissolved secretions of the needle and are distinctive from raindrops. Judging from the pH values, it can be concluded that the presence of seriously damaging acid rain and acid fog is highly likely.

II. The Die-offs of Chongqing's Red Pines

Currently, there are about 27,000 mu of forest at Nanshan, the scenic area on the sourthern bank of the Chang Jiang at the outskirts of Chongqing. It is predominantly artificially maintained red pine forest with small patches of bamboo, black pine (Pinus thunbergii) and camphor trees (Cinnamomum camphora). Since the 1960's, the red pines have not grown well in general and mass die-offs have occurred since 1982. At present, half of them have perished and the remainder face extinction. The local authorities had invited experts to investigate and it was found that the flora of the area was reduced from about 1,000 species to around 260. There is a serious ecological disturbance as evidenced by the damaged vegetation, soil erosion, loss of bird population and disappearances of animals and rampant infestation of diseases and pests. According to the record, there have been 15 episodes of pine moth outbreak during the 31 years since 1953, 2 in the 1950's, 4 in the 1960's, 6 in the 1970's and 3 within the 4 years into the 1980's. Not only has the frequency increased but the extent of damage is also growing. During the 1983 outbreak, the moth/tree ratio was 100 percent and the moth population density reached as high as several thousands. After repeated pine moth devastations, the trees are severely weakened and trunk-boring pests such as long-horned beetles, lesser pine beetles, pine beetles, and weevils flourish. A survey done a year ago showed that two-thirds of the forest was infested with black long-horned pine beetles with 44 percent of the trees dead or dying and merely 2 percent healthy. The hairy-forehead pine beetles also prefer the dead, dying or severely weakened trees. They are not found to damage the healthy ones and are rarely present in the moderately weakened. Besides the trunk-boring species, there are also nematodes, both saprophytic and parasitic, at the xylem. Nematodes in large numbers are found in 94 percent of the dead trees and 71 percent of the dying ones, as high as 437 nematodes per gram of wood having been observed. They are also present in 50 percent of the weakened and 7 percent of the healthy ones but in smaller numbers. It is known that black long-horned pine beetles and lesser pine beetles are the vehicles for the spread of nematodes, which is the cause of the wilting of pine trees. The connection between wilting and the die-offs of Nanshan's red pine is not yet established.

Throughout this investigation we notice that: the trunks of dead trees are covered with signs of pest infestation; the surviving trees grow poorly, pine trees about 30 years old generally having only 3-4 clusters of branches with their crowns about the size of that of a normal young 6- or 7-year-old tree; 2- to 3-year-old pine needles are non-existent and a large proportion of the needles of the young trees display the typical symptoms of sulfur dioxide damage with the symptoms more apparent on the windward side that is closer to and facing the built-up area; there is generally no sign of acute damage in areas far away or not facing direct wind but signs of chronic damage do exist, namely the lack of vitality and the premature dropping of needles. These signs of chronic damage can still be observed at the Nanjiao Park, which is farther away from the city.

The air pollution and acid rain of Chongqing have been systematically monitored. The average concentration of sulfur dioxide within the city is 0.45 mg/m^3 with the highest being 0.72 mg/m^3, 3-4 times the allowed amount on the average. This investigation team carried out a night-time, 7-hour continuous measurement. The average concentration is 0.21 mg/m^3 with the highest being 1.00 mg/m^3. There is a 3- to 4-year record on acid rain in this area. The pH is 4.4 in 1981, 4.2 in 1982, and 4.1 in 1983. The pH drops below 4.0 very frequently. In areas with pest infestations, the pH of the soil is 3.9 with the lowest being 3.6. It is obvious that the pollution is very serious.

III. Analysis of the Causes of the Pine Forest Die-offs

Based on the information gathered by local technicians on their on-site investigations and on our own observations, there is no doubt that the mass die-offs of Huashan and red pine are caused by diseases and pests. But what triggers these rampages of disease and pest?

Diseases and pests exist in the forest and can attack or feed on the plants. But the plants possess a protective mechanism to keep them from becoming devastating. Both sides exist in a state of checked balance. Because the plants' defense mechanisms against diseases and pests and the latter's countermeasures to avoid or overcome the former's defense are not absolutely effective, no one side has the absolute advantage over the other. Therefore, they often co-exist in an ecological system. However, when the internal or external environments are altered, then the breakdown of the old ecological balance can trigger the outbreak of a certain disease or pest. Air pollution is one of such environmental factors.

In recent years, the exacerbation of disease and pest infestations in areas of air pollution have often been reported and there are some information on this aspect in the literature. It is estimated that the disease and pest infestations triggered by air pollution have inflicted greater economic loss to agriculture and forestry than the direct loss caused by air pollution's damages to plants. The air pollution of Chongqing is rather serious and the rural area of Fengjie has many localized pollution sources. The pollutant, sulfur dioxide, has caused acute and chronic damage to the pine trees as evidenced by the symptoms displayed on their needles. But this kind of direct damage is not sufficient to cause death over a large area. The direct causes of the death are diseases and pests. Air pollution and acid rain trigger the outbreak of diseases and pests. The reasons that air pollution help exacerbate certain disease and pest infestations are as follows:

1. The acute and chronic damages caused by air pollution weaken trees and hence provide "hot beds" for the invasion and flourishing of diseases and pests. The majority of trunk-boring pests preferentially attack the weakened or dying trees. Under the circumstances, the increase in pest population actually reflects the increase in the proportion of the weakened trees. The sites of damage caused by pests or air pollution can become windows that are vulnerable to infection.

2. Air pollution disturbs the original ecological balance. Among the pests, some are sensitive to the pollutant while others are resistant. The relationship between the two groups is one of interaction and counterbalance. Air pollution can weaken or even eliminate some pests and boost the others or even cause their numbers to explode.

3. Air pollution alters the physiological and biochemical processes of plants. A number of primary metabolites such as carbohydrates, organic acids, amino acids, proteins, and lipoids are disturbed in the presence of a

pollutant. These changes, though small, can have a significant impact on the feeding pattern and behavior of insects. For example, the Mexican bean beetles prefer the leaves contaminated with sulfur dioxide. After feeding on them, the beetles grow bigger and faster with strong reproductive ability. Secondary metabolites such as flavones, phenolics, steroids, and terpenes also strongly influence the growth and behavior of pests. Among them, terpene is a volatile substance secreted by pine trees and is a chemical signal to insects. The presence of sulfur dioxide in the air will activate the release of terpenes from pine trees, which consequently lures insects toward them.

4. Air pollution causes physical changes in plants. For example, the leaves damaged by sulfur dioxide change color to yellow, brown, dark brown, or black. And the host selection of some insects is strongly influenced by the color. Also, sulfur dioxide induces the dehydration of plant leaves and slight dehydration of leaves is a favorable condition for the growth and propagation of insects.

Through its interaction with plants, acid rain also has impacts on diseases and pests. In general, the impact of acid rain on plants is mostly indirect. Through acidification of soil, it alters the bioactive forms of the metallic elements in soil such as phosphorus, clacium, magnesium, and molybdenum, and hence degrades the nutritional condition for plants and results in reduced growth. The lowering of soil pH increases the solubilities of such elements as iron, manganese, and aluminum to the extent that their concentrations become toxic to the plants. The weakening of plants is another favorable condition for the outbreak of diseases and pests.

In addition to air pollution that causes the die-off of a forest by triggering disease and pest infestations, there are other possible causes. For example, the woods at both locations contain a single species and that usually means a weaker ecological system that is favorable for the spread of diseases and pests. Furthermore, the Maocaoba Forestry Center is located in a cold, high-mountain region with an elevation of 1,500-2,000 meters. There are reports that the damage of Huashan pines is dependent on the elevation. Serious damage occurs at higher altitudes. Hence the deaths are attributed to unfavorable location. There is also a theory that the deaths may have to do with a number of tremendous cold waves experienced in winter because of the climatic irregularity in recent years. It seems that these two factors are not without impact on the growth of Huashan pines. Nevertheless, there is not enough evidence to conclude that they are the main causes of the mass die-off of forests.

IV. Problems and Suggestions

1. At present, the rural industries are booming and making significant contributions to the modernization of China. But a by-product is the problem of air pollution being spread from urban to rural areas and progressing from individual pockets to cover whole areas. Many rural factories have severely polluted villages and small towns and this pollution is being fed back to cities in the form of agricultural products. Here, it also involves a basic question of how to develop industry: is it appropriate to develope certain industries in rural areas by a cluster of small, backward operations?

Generally speaking, rural areas do not have adequate tehcnological background. Running a primitive shop often is a waste of resources and causes serious pollution of three industrial wastes. Take Maocaoba as an example. Operating sulfur plants to fully utilize the local sulfur-containing ores is an important approach to advance the economy of this mountain region. But, at present, these small plants have caused severe problem for forestry productions by polluting the air due to their obsolete technological processes and their lack of facilities to treat the three industrial wastes. Although the plant operators may profit in hundreds of millions of yuans, the national forestry industry stands to lose hundreds of millions. Since the establishment of the forestry center in 1958, the state had invested a total of 3.6 million yuan up to 1984. Now, 90,000 mu of forest are dead with a loss of 12 million yuan worth of timber. This is only the financial balance sheet. As to the ecological effect, the damage is incalculable. And the impact is not limited to our generation. Future generations will suffer too. Weighing the pros and cons, it appears inappropriate for such industries as sulfur plants to be run in the rural areas by a cluster of small and primitive operations.

2. Reports of air pollution causing the death of large areas of forests have appeared in Scandinavia, central Europe, and North America. Now it has happened in China: the death of a forest is caused by rural air pollution at Maocaoba and by urban air pollution at Chongqing. Chongqing is one of China's cities having air pollution. The acid rain in its area is also serious. Within the city, trees lining the streets are gradually being eliminated by air pollution and only pistache trees survive. The red pines on the outskirts are the first to suffer damage due to their sensitivity to sulfur dioxide. If the pollution continues, other species will follow. Agriculture and forestry are but one aspect of the loss. The corrosion of machineries, buildings and equipments by acidic pollutants as well as the threat of human health deserve more attention. What is happening here can serve as a warning to other large cities.

3. There are several unique features in forestry production: besides economic, benefits, forest regeneration also has short- and long-term environmental impact; it has an especially long production cycle and is extremely susceptible to the influence of environmental factors including natural and man-made disasters. Therefore, the policies governing the forestry production units at all levels ought to be different from those of industry and agriculture. As far as the Maocaoba Forestry Center is concerned, 20 years of painstaking efforts are wasted. It faces the tremendous task of generating anew the whole forest. According to the decision of higher authorities, the budget for the center will be eliminated, effective September 1984. It has to seek its own financial resources. Thus, the Center faces the situation of "close-down, stop operation, merge, or switch." Through 20 years of investment by the state, the Center has just established itself with a team of specialists. Although it is in a very difficult situation at the moment, its employees and staff all express their willingness to hang on. The nearby Sanxia project will soon start and the works on the water and soil retention along the riverbanks should be kept at the same pace. Trees should be planted without any delay. The state should

give forestry centers like this one the kind of support usually given in emergencies.

4. Take on the comprehensive study of forest environmental protection. The above analysis of the causes of the death of forests is only the preliminary results of a short-term investigation. The connection between the forest die-offs at both locations and air pollution and acid rain is confirmed. But to what extent? How about the other environmental factors? To clarify these points requires systematic observations and studies. Whether from the practical or theoretical point of view, the correlation between the disease and pest infestation in plants and air pollution is a particularly important and significant subject. Yet this is basically an untouched area in China. The urgent tasks in front of us are to carry out further study on the causes of the die-offs in order to find effective countermeasures to save forests in other areas and to draw up forest regeneration plans. Such a study involves many disciplines including forestry, environmental sciences, plant protection, plant physiology and biochemistry, soil science, and meterology, and needs a multi-disciplinary approach. In the past, it was often done by engaging a single discipline to study only one aspect of the problem. As a result, the conclusions and countermeasures were rather limited in scope. These lessons should be well remembered.

12922/12913
CSO: 4008/40

NUMERICAL PREDICTION OF SUPERSONIC BOUNDARY-LAYER TRANSITION

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 4, 1985 pp 9-18

[English abstract of article by Zhang Guanghua [4545 0342 5478] and Yang Hui [2799 6540] of Qinghua University]

[Text] In this paper the turbulence model developed by Wilcox and Traci for predicting boundary-layer transition has been improved in some aspects. A series of numerical experiments have been performed on the improved model to predict the supersonic boundary-layer transition on a sharp cone with zero angle of attack. The computational results are compared with the wind-tunnel test data reported by van Driest and Boison. Satisfactory agreement between numerical and wind-tunnel experiments is obtained in many major aspects.

MOVEMENT OF HYDROMETEOR PARTICLE CLOUD IN BOW SHOCK LAYER

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 4, 1985 pp 28-34

[English abstract of article by Zhao Guoying [6392 0948 5391] of the Institute of Mechanics, Chinese Academy of Sciences]

[Text] During reentry, high speed vehicles may encounter condensed phase H_2O in the form of ice particles or liquid droplets, which form so-called particle clouds. These particles must traverse the shocked air layer enveloping the reentering vehicle prior to impacting the surface. The interaction between the gas and the particles in the shock layer is usually investigated by calculating the trajectory of every particle in the gas flow field without consideration of the presence of other particles (this method is called one-way coupling). This paper presents a gas-(solid and liquid) particle two-fluid flow model, including the interaction (i.e., the mass, momentum and heat transfer) between the two phases (that is, a two-way coupling is taken into account), and the dissociation and ionization of the air and the dissociation of the steam (from the particle cloud). The model is solved by using the line method. The flow field of gas and the particle cloud is obtained, and the applicable range of one-way coupling is studied. Finally some interesting discussions are presented.

KERNEL FUNCTION METHOD FOR UNSTEADY TRANSONIC FLOW PAST LOW-FREQUENCY OSCILLATING BODIES OF REVOLUTION

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 4, 1985 pp 45-54

[English abstract of article by Cheng Jianyu [4453 0256 1342] and Zhuang Lixian [8369 4409 6343] of the University of Science and Technology of China]

[Text] An approximate method is developed to calculate the unsteady surface pressure distributions and stability derivatives for elongated axisymmetric bodies of revolution undergoing harmonic pitching oscillations in transonic flow. The analysis is based on the time-linearized transonic small disturbance equation and the concept of local linearization. An integral equation is obtained and solved numerically with the panel method. Some results of the present method are compared with those of other theoretical methods and experiments.

NORMAL FORCE CHARACTERISTICS OF SHARP NOSED BODIES OF REVOLUTION AT HIGH ANGLES OF ATTACK IN SUBSONIC AND TRANSONIC FLOW

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 4, 1985 pp 81-89

[English abstract of article by Tu Xing [1458 5281] and Wu Wenkang [2976 2429 1660] of Northwestern Polytechnic University]

[Text] The normal force characteristics of sharp nosed bodies of revolution were investigated experimentally at high angles of attack in a Mach number range from 0.35 to 1.20. The test results were analyzed. It was shown that both the Mach number and the Reynolds number strongly influence the normal force characteristics. The calculation methods based on crossflow theory had not taken into account the effects of viscosity and compressibility, so the actual phenomenon could not be represented.

The present research also investigated the effect of rolling orientation on the normal force characteristics experimentally. It was shown that the vortex pattern on the leeside surface has a considerable effect on the normal force coefficient. The difference of the normal force coefficient for different rolling orientations is approximately the same as the magnitude of the Mach number effect. For sharp nosed bodies of revolution the vortex pattern on the leeside surface cannot be predicted precisely. For the same model, at the same angle of attack, the vortex pattern is different with different rolling orientations. Therefore, we can predict that the aerodynamic characteristics of sharp nosed bodies of revolution at high angles of attack should not be unique, and they can vary within a certain range.

EXPERIMENTAL INVESTIGATION OF TURBULENT JET

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese No 4, 1985 pp 90-97

[English abstract of article by Ke Liwen [2688 2621 2429] and Yan Xiqin [7051 0823 0530] of Beijing Institute of Aerodynamics]

[Text] The measurements of a turbulent jet have been made using a crossed hot-wire anemometer. The air jet issues from four nozzles with diameters of 3.91, 5.53, 8.74 and 12.36 mm respectively. The ambience is still air. The issuing velocity of the jet is from 16 m/s to 270 m/s. The measurements have been divided into four parts: (1) The longitudinal variations of the mean velocity and turbulence intensity on the jet axis; (2) The radial distribution of mean velocity, turbulence intensity and shear-stress in the fully developed region; (3) Third and fourth order moments; (4) Self-correlation coefficient and one-dimensional spectra of u_z on the jet axis.

9717
CSO: 4009/39

Lasers

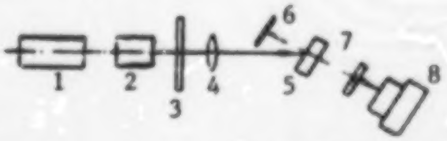
LASER OUTPUT PROPERTIES OF A NEW CHINESE MADE DYE OXAZINE (1)

Hefei ZHONGGUO KEXUE JISHU DAXUE XUEBAO [JOURNAL OF CHINA UNIVERSITY OF SCIENCE AND TECHNOLOGY] in Chinese Vol 15 No 3, Sep 85 pp 265-270

[Article by Ma Yurong [7456 3768 5554] and Tan Shici [6223 4258 1964] of Department of Physics, China University of Science and Technology, and Li Feng [2621 4539/7364] of Tianjin Institute of the Dyestuff Industry]

[Abstract] A high laser otput was obtained with a new type dye, oxazine (1), pumped by an electro-opto-Q-switching double frequency YAG laser. The bandwidth of the laser output is 6650 to 7070Å; the center wavelength is 6860Å. The output versus concentration curves were plotted. When the pumping power remained constant, the laser output was the highest at an optimal oxazine (1) concentration. Its output intensity and the laser conversion efficiency depend heavily on pumping intensity; i.e., the stronger the pumping intensity, the higher the laser output and the conversion efficiency.

An experimental setup of the YAG double frequency laser pump dye oxazine (1) is shown in the following:



Key:
1. YAG laser
2. Lithium niobate frequency multiplier
3. Light filter with total reflection at 1.06 micrometers and transmission at 0.53 micrometer
4. Focusing lens
5. Dye box
6. 6900Å total reflecting mirror
7. 6943Å semireflecting mirror
8. Receiver

Six other figures show an absorption property curve and a fluorescence property curve of oxazine (1) spectral property of laser output, laser pulse waveform of oxazine (1) and pumping light pulse waveform, the effect on laser conversion efficiency by different concentrations of methyl alcohol in oxazine (1), and the relationship between laser conversion efficiency and the pumping light intensity. One table lists data showing the relationships of output intensity, conversion efficiency, and concentration.

The paper was received for publication on 3 January 1985.

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10424/9365
CSO: 4009/29

VIBRATIONAL ENERGY TRANSFER STUDY OF DICHLOROMETHANE (CH_2Cl_2) BY LASER INDUCED FLUORESCENCE METHOD

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1261-1268

[English abstract of article by Gao Wenbin [7559 2429 2430] and Shen Yuqi [3088 3768 0366] of Anhui Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, Hefei; and J. Häger and W. Krieger of Max-Planck-Institut für Quantenoptik, FRG]

[Text] In this work, the vibrational energy transfer of the organic molecule CH_2Cl_2 was studied with the laser induced fluorescence method for the first time. The activation and deactivation rate constants of modes ν_8 and ν_3/ν_9 of pure CH_2Cl_2, as well as the effect of rare gases on the deactivation processes for ν_3/ν_9, were obtained. The relative probabilities of energy transfer from the ν_3/ν_9 vibrational modes of CH_2Cl_2 to a translatable degree of freedom were calculated by means of SSH theory for the collision relaxation processes of the CH_2Cl_2-rare gas mixtures. A vibrational energy transfer channel in CH_2Cl_2 is also discussed.

CRITICAL PHENOMENA IN OPTICAL BISTABILITY AND CHAOTIC MOVEMENT

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1233-1240

[English abstract of article by Wang Pengye [3769 7720 2814], Zhang Hongjun [1728 3163 6874] and Dai Jianhua [2071 1696 5478] of the Institute of Physics, Chinese Academy of Sciences]

[Text] The critical phenomenon of bistability is discussed based on the relaxation equation of nonlinear systems with time-delayed feedback. We find that the critical slowing down at the edges of the bistable region is consistent with the divergence of the time duration of intermittency. The critical exponent is 1/2. We also find that, aside from the critical points at the bistable region edges, there are consistencies within the period-doubling bifurcation points and split bifurcation points at the cusp point (in the cust catastrophe model of bistability). The critical exponent is 1. The above-mentioned results possess universal properties. The computer experiments were conducted in a liquid crystal hybrid optical bistable device. The results are in agreement with the analyses.

STUDY OF TRANSIENT OPTICAL BISTABILITY OF QUASI-RESONANT-ABSORPTIVE DYE MEDIUM

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85
pp 1241-1248

[English abstract of article by He Guangsheng [6378 0342 3932], Zhou Fuxin [0719 4395 2450] and Liu Songhao [0491 7313 6275] of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Text] Using an intense pulsed laser beam of 5320 Å to excite the BDN dye solution inside the F-P interferometer, we have fcund the transient and intrinsic optical bistability effect. The various possible mechanisms for inducing the refractive-index change of the sample medium and their relative contributions have been estimated. Also, it is confirmed that during the input laser pulse the refractive-index variation increases with time approximately in the form of a semi-cubic parabola, and the main mechanism causing this variation is the opto-thermal effect of the sample medium.

INFRARED DIVERGENCE THEORY OF ULTRASONIC ABSORPTION IN GLASSES

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85
pp 1269-1279

[English abstract of article by Fan Xiqing [5400 1585 1987], Wang Guoliang [3769 0948 2856] and Dai Peiying [2071 1014 5391], et al., of the Department of Physics, Zhengzhou University; and Liu Fusui [0491 4395 4840] of the Department of Physics, Beijing University]

[Text] Starting from Ngai's unified theory of low-frequency fluctuation, dissipation and relaxation processes, we studied the ultrasonic absorption in the thermal activation process in glasses. The theory involves only a single relaxation time and differs from the theory of distributed relaxation times. Nonetheless, it can explain the experimental characteristics of ultrasonic absorption in glasses and the universality of these characteristics, independent of kinds of materials, which could not be interpreted by the previous theory on the distribution of relaxation times.

AN ASED-MO STUDY OF THE MICRO MECHANISM OF ACTIVATION OF CO ADSORBED ON Ni(100) AND POISONING BY THE SUBMONOLAYER S ATOM

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1291-1298

[English abstract of article by Cao Peilin [2580 1014 2651] and Shi Danhua [2457 0030 5478] of the Department of Physics, Zhejiang University, Hangzhou]

[Text] Using an atom superposition and electron delocalization molecular orbital (ASED-MO) theory, the micro-mechanism of activation of CO adsorbed on Ni(100) and of poisoning by the submonolayer S atom is studied. CO is found to bond to the top site more strongly than on the fourfold site. When CO is adsorbed on the top site, it will get 0.72e on its antibonding 2π orbital, and its dissociation energy will reduce from 11.1 eV for a free CO molecule to 2.15 eV. If CO is adsorbed on the fourfold site, the electrons on its 2π orbital will be 1.22e and dissociation energy 1.85 eV. It seems likely that CO adsorbed on the fourfold site is more active. Our binding energy calculations have verified that one S atom adsorbed on Ni(100) will inhibit the four nearest top sites and the four nearest fourfold sites from adsorbing the CO molecule, but will not significantly affect farther sites. These results support the idea that the dominant effect of adsorbed S atoms is the "structural effect." The "blockage" effect by the adsorbed S atom, i.e., the reduction of the active sites, and some other factors result in the poisoning of Ni surfaces by the submonolayer S atom.

INVESTIGATION OF CO AND NO CHEMISORPTION ON VIII GROUP TRANSITION METAL SURFACE BY X_α-DV METHOD (I). ELECTRONIC STRUCTURE OF CHEMISORPTION OF CO ON Rh(111) SURFACE

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1299-1305

[English abstract of article by Chen Yunqi [7115 5366 3875] and Zheng Dejuan [6774 1795 1227] of the Institute of Physics, Chinese Academy of Sciences; and Cao Peilin [2580 1014 2651] and Wu Yue [0702 6885] of the Department of Physics, Zhejiang University, Hangzhou]

[Text] In this paper, the electronic structure of chemisorption of CO on a Rh(111) surface ($\theta \leq 1/3$) has been calculated by the self-consistent Hartree-Fock-Slater molecular cluster method. The variation of the energy levels and total energy with respect to the vertical distance of the CO molecule above this surface is obtained. The optimized bond distance determined from the total energy curve is 1.85 Å, which is quite close to the experimental results of 1.95 ± 0.1 Å. The binding energy is 0.98 eV, which is smaller than the experimental adsorption energy of 1.3 eV. The total density of states with the above bond distance is calculated, and it is in good agreement with the UPS results which consider the final state and relaxation effect. The bonding and antibonding characteristics for the CO valence level have also been studied by analysis of the variations of the molecular eigenvalues when the CO molecule approaches the surface. The charge transfer for CO chemisorption on the transition metal Rh is investigated through Milliken population analysis and the analysis of coefficients of the cluster wavefunction, which is expanded using the CO molecular wavefunction. This charge transfer causes the activation of absorbed CO molecules.

INVESTIGATION OF CO AND NO CHEMISORPTION ON VIII GROUP TRANSITION METAL SURFACE BY X_α-DV METHOD (II). CHEMISORPTION OF NO ON Pd(111) SURFACE

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1306-1314

[English abstract of article by Wu Yue [0702 6885] and Cao Peilin [2580 1014 2651] of the Department of Physics, Zhejiang University, Hangzhou; and Chen Yunqi [7115 5366 3875] and Zheng Dejuan [6774 1795 1227] of the Institute of Physics, Chinese Academy of Sciences]

[Text] The chemisorption of NO on Pd(111) surface is calculated using the X_α-DV method. Its electronic structure, including the spectrum of the ground state valence levels, density of states and the charge transfer between the adsorbate and substrate, is obtained. The interaction between adsorbed NO molecules is included in the calculations. The results of DOS are in good agreement with UPS, supporting the LEED structural analysis, and the adsorption height is determined to be 1.27 Å. The theoretical results verify that the interaction between NO molecules is important in the chemisorption of NO on Pd surfaces. The activation of adsorbed NO on Pd(111) is discussed. It is evident from the results that the charge transfer between adsorbed NO and the substrate is similar to CO adsorption on transition metals. Finally, it was found that the adsorption of NO does not significantly affect the valence band of Pd.

EXPERIMENTAL DETERMINATION OF THE STEREOCHEMICAL STRUCTURE OF H_3^+

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85 pp 1315-1321

[English abstract of article by Miao Jingwei [4924 4552 1218] and Yang Baifang [2799 4102 2450], et al., of the Institute of Nuclear Science and Technology, Sichuan University, Chengdu]

[Text] The measurement of the stereochemical structure of the H_3^+ molecular ion is reported. This measurement makes use of the Coulomb explosion of a fast molecular ion. It is shown that the structure is equilaterally triangular in shape. The mean value of the most probable interproton separations is found to be 0.98 ± 0.03 Å. Also described is a set of high resolution experimental arrangements.

PRESSURE EFFECT ON THE STABILITY AND PHASE TRANSFORMATION OF THE ε-PHASE IN SPLAT QUENCHING Fe-C-Sb ALLOY

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85
pp 1322-1326

[English abstract of article by Qin Zhicheng [4440 1807 2052], Chen Xichen [7115 3556 3819] and He Shouan [0149 1108 1344], et al., of the Institute of Physics, Chinese Academy of Sciences]

[Text] The pressure effect on the phase transformation process of the ε-phase of a splat quenching Fe-C-Sb alloy has been investigated using X-ray powder photography. The experimental results show that high pressure will not only increase the stability of the ε-phase remarkably, but will also change its phase transformation process. At 4.7 GPa, as the stability temperature of the ε-phase increases to 450°C, a new metastable phase of orthorhombic structure, absent at normal pressure, will appear. By raising the annealing temperature to 560°C, the orthorhombic metastable phase begins to transform into Fe_3C, which will decompose into carbon (graphite) and γ-Fe when the annealing temperature is further increased to 800°C. At this time, the alloy is composed of C (graphite), γ-Fe, Sb and another unknown phase.

THE CRYSTALLIZATION PROCESS OF METGLASS $(Fe_{0.1}Co_{0.55}Ni_{0.35})_{78}Si_8B_{14}$ AND THE EFFECT OF HIGH PRESSURE (II). THE CRYSTALLIZATION TEMPERATURE AND THE CRYSTALLIZATION ACTIVATION ENERGY

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85
pp 1327-1335

[English abstract of article by Shen Zhongyi [3088 0022 3015], Zhang Yun [1728 0061] and He Shouan [0149 1108 1344], et al., of the Institute of Physics, Chinese Academy of Sciences; and Chu Shaoyan [0328 1421 1484] of Nanchang Aviation Institute]

[Text] In this paper the pressure dependence of the crystallization temperature T_x and the crystallization activation energy ΔE_x of metglass $(Fe_{0.1}Co_{0.55}Ni_{0.35})_{78}Si_8B_{14}$ are studied by measuring the electrical resistivity in-situ under pressure of up to 3 GPas. It is found that application of high pressure does not raise the T_x linearly, or even monotonically, as is usually described in the literature about pressure dependence of T_x in metglasses, but instead shows some local detours on the T_x vs P curve in a generally rising tendency. ΔE_x shows some behavior that is analogous to that of T_x as the pressure rises.

An analytical discussion indicates that pressure promotes the nucleation process and restrains the diffusional growing of the crystallized nuclei on heating the metglass. As a combined result of the mutually contrasting effects of pressure on nucleation activation energy and diffusion activation energy, the above-mentioned non-monotonic rising behavior of ΔE_x and T_x of the metglass studied is produced. In addition to ΔE_x, pressure may also markedly affect the preexponential factor and produce a considerable change of the crystallization temperature.

STUDIES OF THE STRUCTURE OF AMORPHOUS MoS_3 AS CATHODE MATERIALS IN LITHIUM BATTERIES

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 34 No 10, Oct 85
pp 1336-1341

[English abstract of article by Guo Changlin [6753 1603 7207] and Lu Changwei [7120 2490 0251], et al., of Shanghai Institute of Ceramics, Chinese Academy of Sciences; and Yu Zhizhong [0205 1807 0022] of Shanghai Institute of Testing Technology]

[Text] The structure of amorphous MoS_3 as the cathode material in lithium batteries was studied using the X-ray diffraction method and X-ray photoelectron spectroscopy. The results reveal that the structure of amorphous MoS_3 is built by homogeneously randomly stacking the MoS_2 basic unit S-Mo-S sandwich layers and the amorphous sulphus chains S_n.

9717
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Polymers and Polymerization

STUDIES ON THE POLYMERIZATION OF BUTADIENE IN THE PRESENCE OF IRON CATALYST

Beijing GAOFENZI TONGKUN [POLYMER COMMUNICATIONS] in Chinese No 4, Aug 85 pp 258-262, 257

[Article by Liu Gouzhi [0491 0948 2535] and Wang Fengjiang [3769 7364 3068] of the Changchun Institute of Applied Chemistry, Chinese Academy of Sciences]

[Abstract] It was found that the addition of compounds containing one nitrogen atom, such as pyridine, does not raise the catalitic activity in the polymerization of butadiene for the system of $FeCl_3-(i-C_4H_9)_3Al$, and that the compounds containing two nitrogen atoms can increase the activity in the following order: 1, 10-phenanthroline 2, 2'-dipyridyl>>ethylenediamine or tetramethyl ethylenediamine. The polymerization of butadiene in the presence of $FeCl_3-(i-C_4H_9)_3$ Al-phenanthroline have been studied in more detail. A possible mechanism is proposed. (Paper received 7 May 1983)

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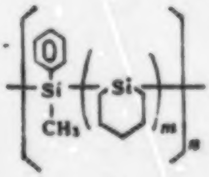
CSO: 4009/1027

SYNTHESES AND PROPERTIES OF SOME ORGANOSILANE POLYMERS

Beijing GAOFENZI TONGKUN [POLYMER COMMUNICATIONS] in Chinese No 4, Aug 85
pp 274-281

[Article by Zhang Xinghua [1728 5281 5478] of the Institute of Chemistry, Chinese Academy of Sciences, Beijing, and Robert West, Department of Chemistry, University of Wisconsin, Madison, Wisconsin]

[Abstract] Some organosilane polymers [see figure] with high molecular weights have been synthesized by cocondensation of organosilicon dihalide monomers with sodium metal in toluene. These polymers are readily soluble in common solvents and can be molded, casted into films or drawn into fibers. Upon exposure of the solid polymers to ultraviolet light the polymers tend leads to produce degradation or crosslinking. (Paper received 26 May 1983)



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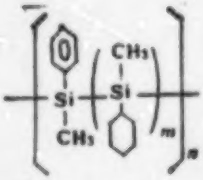

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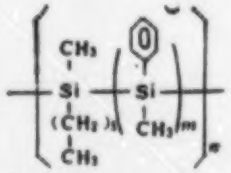

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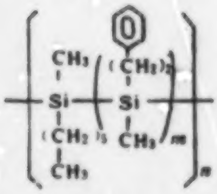

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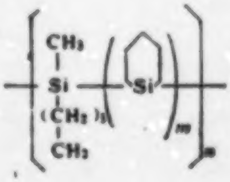

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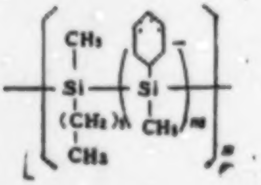

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Solar Energy

DEVELOPMENT OF ALL-GLASS EVACUATED TUBULAR COLLECTORS WITH BLACK CHROMIUM SELECTIVE COATINGS AND V-SHAPED SPECULAR REFLECTORS

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6 No 4, Oct 85 pp 341-346

[English abstract of article by Li Minghua [2621 2494 5478], Shi Xuejun [2457 7185 0689] and Wu Shuzhen [0702 4790 6297] of Shanghai Institute of Ceramics, Chinese Academy of Sciences]

[Text] In this paper the construction and performance of an all-glass evacuated tubular collector are introduced. The collector panel is composed of thermal collection vacuum tubes, manifold, frame and V-shaped specular reflectors. An evaporated black chromium selective film is coated on the outside of the inner absorber element. It is shown that, as a result of optimizing geometric parameters and the design of the V-shaped mirror reflector, the collector performs well in solar thermal conversion.

With the improvements if the manufacture of the manifold and fixation of the thermal collection tube, the collector possesses such excellent advantages as lower cost and ease in maintenance. These collectors are potentially applicable to solar industrial processing heat.

THE NATURE AND APPLICATIONS OF COBALT OXIDE COATING

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6 No 4, Oct 85 pp 347-352

[English abstract of article by Wang Guohua [3769 0948 5478] and Yuan Jinshe [5373 6651 4357] of Xinjiang Solar Energy Research Institute]

[Text] A new technique of spray pyrolysis is reported which produces cobalt oxide coating on aluminum plate. The surface microstructure of the coating is studied by electron microscope, and structural and optical properties of the coating are analyzed in detail. Test studies indicate that this coating has good adhesion to the substrates and is stable up to 400-600°C. The cobalt oxide selective surface has high absorption over the spectral range of the solar spectrum combined with low thermal losses due to reradiation at longer wavelengths. The α_s ε_n value is usually equal to 3-4.

PHOSPHORUS (P) DOPING EFFECTS ON THE ABSORPTION COEFFICIENT AND DENSITY OF GAP STATES OF a-Si:H

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6 No 4, Oct 85 pp 353-358

[English abstract of article by Wu Zongyen [0702 1350 8746] and Shen Yuehua [3088 2588 5478] of Shanghai Institute of Ceramics, Chinese Academy of Sciences]

[Text] The absorption coefficient of a-Si:H maps out the distribution of density of states above the valence band; the parameter γ from steady photoconductivity measurements may give information on the exponential conduction band tail. This paper describes P doping effects on a-Si:H gap states by means of these two parameters. Light doping raises only the density of deep states in the gap, while heavy doping increases the width of the valence band tail as well. However, doping has no obvious effect on the conduction band tail. Therefore, the decrease of the optical gap with doping is due only to the variation of the valence band tail.

EXPERIMENTAL INVESTIGATION OF HEAT LOSS CHARACTERISTICS OF AN EVACUATED TUBE COLLECTOR

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6 No 4, Oct 85 pp 372-376

[English abstract of article by Zheng Zhenhong [6774 2182 1347] and Huang Zhicheng [7806 1807 2052], et al., of Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences]

[Text] Heat loss from an evacuated tube collector and results of its experimental investigation are presented in this paper. The variation of heat loss rate with the vacuum degree, the effect of the vacuum degree on the heat loss, and the variation of the overall heat loss coefficient with the temperature difference are found. Heat loss from the vacuum tube can be reduced when the vacuum gap is filled with some kind of low thermal conductivity gas with the range of 1-10 torr.

EVAPORATED SiO COATING AND SERIES RESISTANCE FOR SILICON MIS/IL SOLAR CELLS

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6
No 4, Oct 85 pp 377-382

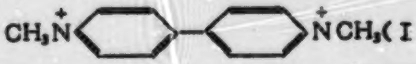
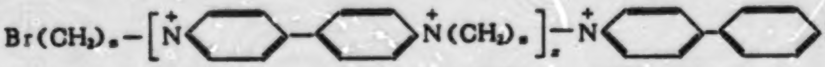
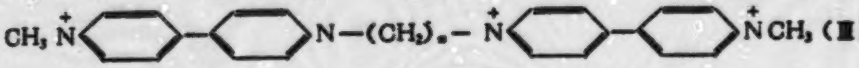
[English abstract of article by Zhang Xiumiao [1728 4423 8693] of the Department of Physics, Hangzhou University]

[Text] In this paper the series resistance for silicon MIS/IL solar cells related to the thickness of the evaporated SiO coating, the fixed positive charge density in the coating and the interface state density is indicated. The results show that in the case of the minimum thickness of the SiO coating required by antireflection property in order to decrease the series resistance to an acceptable level, it is important to increase the fixed positive charge density in the coating and to decrease the interface state density technologically.

INVESTIGATION OF SEVERAL VIOLOGENS AS ELECTRON RELAY BY ELECTROCHEMICAL METHODS

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6 No 4, Oct 85 pp 383-391

[English abstract of article by Tang Huanyi [3282 3562 3015], Sun Mingshan [1327 2494 1472] and Wang Wenquan [3769 2429 0356], et al., of Dalian Institute of Chemical Physics, Chinese Academy of Sciences]

[Text] Three types of viologens,  (I)  (II) and  (III) were studied comparatively. Their redox characteristics and reversibility in redox were investigated by the multicyclic potential sweeping technique, and the formation as well as the change of the reduced viologens produced during controlled potential electrolysis was followed by absorption spectra in situ. The behavior of photoelectrochemical cells containing different viologens was also examined. (I) was found to possess a more negative redox potential and a greater ability for electron transfer, but was less stable with oxygen. The absorption spectra of the reduced state V^+ of (II) and (III) were shown to be violet shifted when compared with those of MV^+. A serious problem in reversibility of the viologens was confirmed to be due to the formation of V^0 and their aggregation. In order to improve the stability of the catalyst system for H_2-photogeneration from water, it was proposed that the viologen and photosensitizer used as catalyst components should possess the potential order $E_{(H_2O/H_2)} > E_{(V^{2+}/V^+)} > E_{(PS^+/PS^*)} > E_{(V^+/V^0)}$, and the reaction condition should be adjusted in such a way that the evolution of hydrogen would match the formation of V^+ in velocity.

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China Report

SCIENCE AND TECHNOLOGY

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SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

U.S. STRATEGIC DEFENSE INITIATIVE REVIEWED

Beijing HANGKONG ZHISHI [AEROSPACE KNOWLEDGE MAGAZINE] in Chinese No 2, Feb 86 pp 10-12

[Article by Zheng Zhiren [6774 3112 0068]]

[Text] The U.S. "Star Wars" plan is currently a topic of great controversy and an issue for heated debate among different nations, particularly between the two superpowers and the Western European countries.

With regard to the "Star Wars" plan, people are concerned not only about its contents, but more importantly, they are concerned with the following questions: What is the United States' main motives behind this plan? Why did the Soviet Union react so strongly? Is the "Star Wars" plan truly as "omnipotent" as advertized? What is the possibility of this plan actually being realized?

The implementation of the "Star Wars" plan is divided into two phases. The first phase, which extends from FY 1984 to FY 1989, is concerned with feasibility studies and verification; specifically, it covers the following five areas: search, acquisition and tracking technology, directed-energy weapons technology, kinetic-energy weapons technology, system analysis and battle management techniques, and defense system technology. The second phase is concerned with whether and how this anti-missile system will be developed in the 1990's.

Therefore, the basic design of the "Star Wars" plan--a new anti-missile system--is far from being finalized. The many introductory articles which discuss the so-called multi-stage, multi-approach, space-based anti-missile systems only deal with the basic principles and general approaches of the current concept.

According to this concept, the intercept of an attacking missile can be divided into four stages:

First stage: boost phase intercept, which is the stage immediately after launch; it lasts approximately 3-5 minutes, during which time the missile continues to climb upward. During this period, the missile emits large amount of infrared radiation, which can be easily detected by early-warning satellites; the intercept weapons used are X-ray laser weapons (anti-missile satellites). Theoretically, each satellite can destroy more than 100 ascending missiles.

Second stage: post-boost intercept. During this stage, the rocket is shut off, and the warhead (including the bus and the individual warheads) and penetration aids begin to separate from the missile and fly toward the target. At this time the missile is still emitting easily-detected infrared rays. During this stage, which lasts approximately 500 seconds, laser weapons or kinetic-energy weapons can be used to destroy the already-deployed warheads and the bus which may still contain undeployed warheads.

Third stage: mid-course intercept. The mid-course is defined as a 20-minute period between deployment of warheads and penetration aids and re-entering of the warheads back to the atmosphere. Intercept is difficult during this stage because of the large number of warheads and decoys. Generally, electromagnetic guns and non-nuclear intercept missiles are used to perform the intercepts.

Fourth stage: final stage intercept. After the warheads re-enter the atmosphere, intercept can be accomplished using anti-missile missiles, kinetic-energy weapons, and particle-beam weapons.

It is alleged that the probability of intercept for each stage is 90 percent; thus the overall probability of intercept of such a multi-stage, multi-approach defense system can be as high as 99.99 percent.

Struggle for Military Dominance in Space

Why did the United States announce its intention to develop the "Star Wars" plan? And why did the Soviet Union react so strongly to oppose the plan? The answer, very simply, is the fight for military dominance in space. At present, the Soviet Union and U.S. strategic nuclear forces consist of the "triad"--ICBM's and IRBM's, SLBM's, and strategic bombers; both sides are also striving to include strategic cruise missiles as part of their strategic forces. In the foreseeable future, which may extend beyond the end of this century, this balance of power is not likely to change. Therefore, both sides realize that the potential of continuing to develop strategic forces on earth is very limited; the struggle for strategic advantage must be shifted to space.

Before the United States announced its "Star Wars" plan, the struggles for space were carried out largely in secret, with no publicity. In most people's mind, the United States seemed to be always ahead in this struggle. Actually, this was a misconception. In fact, the military struggle in space between the two superpowers has also been a toss-up. It has even been predicted that if the United States does not take additional measures, and the current trend is allowed to continue, superiority in space may quickly shift toward the Soviet Union. Today, the Soviet Union clearly has advantages in the following areas:

1. Manned Space Flight

On 12 April 1961, the Soviet Union launched the first manned spacecraft, thus lifting the curtain for manned spaceflight technology. On 8 February 1984, three Soviet astronauts set a new record of orbiting continuously in space for 237 days. According to a U.S. Department of Defense estimate, by 1990 the Soviet Union will have a large, permanent space station capable of attacking any targets on the ground, on the ocean or in the air. Manned spacecraft has great military value; it is not only more effective than unmanned spacecraft, but can also selectively carry out reconnaissance and monitoring missions on ground targets, and provide command and control functions for ground forces. By establishing a transportation link between the space station and earth, it is possible to assemble a large military facility in space for the purpose of deploying intercept missiles, satellite defensive weapons, and offensive weapons which can attack targets on the ground or in space. On the other hand, only in a statement given by President Reagan on 25 January 1984 that the United States announced its intention to develop a permanent manned station in space within 10 years. Clearly, even if this goal is realized, they will still be behind the Soviet Union.

2. Anti-Satellite Weapons

Since the early 60's, the Soviet Union has been engaged in the development of anti-satellite weapons. It has gone through the early phase of technology development, the flight test phase, the improvement phase, and since 1979, it has entered the phase of actual war exercise. The Soviet anti-satellite satellites require very short launch-preparation time (less than 1 hour), and can perform intercepts at high altitudes (2000 km) and with high speeds (can approach and intercept targets within one orbit); but more importantly, the anti-satellite tests are sometimes coordinated with military exercises on the ground, indicating that the Soviet anti-satellite satellites have already reached a stage where they can be deployed in actual warfare. It represents a new military force in addition to the Army, the Navy, the Air Force, and the strategic Rocket Forces. In the United States, two non-nuclear anti-satellite missile tests were conducted in the western test ranges using F-15 aircraft on 22 January and 13 November 1984. It is estimated that they will be ready for deployment in 1987, apparently behind the Soviet Union. In fact, the United States is very concerned about the disparity in anti-satellite weapons between the two countries.

3. Deployed Anti-Missile Systems

Since 1964, the Soviet Union has been deploying the "rubber Galoshes" anti-missile system around Moscow, which includes four missile sites and 64 missile launchers; the capability of this sytem has been under continuous improvement over the years. This is the only deployed anti-missile system that exists in the world today. The United States on the other hand, does not have a deployed anti-missile system. In August 1984, the U.S. discovered that 68 silos had been built around Moscow which could accommodate the newly developed SH-04 and SH-08 anti-missiles. In September, the U.S. also discovered the construction of a large phased-array radar near Moscow for commanding the anti-missile system.

Of course, in some areas the United States has made significant breakthroughs and is ahead of the Soviet Union. For example, on 10 June 1984, 185 km above Kwajelein Island in the Pacific, an infrared-guided non-nuclear intercept missile destroyed by direct collision a Minuteman-I simulated ICBM warhead which was launched 30 minutes earlier from Vandenburg Air Force Base; this was the first direct intercept of an ICBM by an anti-missile missile. In October 1984, the United States successfully tested an X-ray laser in the laboratory, which was a major breakthrough in X-ray laser research. On 21 June 1985, an argon laser experiment was successfully performed on the Space Shuttle "Discoverer". The success of this experiment verified the capability of a laser to track a high-speed object (the Space Shuttle was in a 354-km orbit and moving at a speed of 8 km/sec), and for the first time demonstrated the feasibility of using a space-based laser/mirror design in an anti-missile system. On 13 September 1985, the United States used a small anti-satellite missile to destroy an old scientific satellite in orbit by direct collision; this was the first successful intercept of a satellite using kinetic-energy weapons.

Now, the United States has changed its previous position and openly announced the "Star Wars" plan. Aside from political and psychological reasons and trying to pressure Congress to allocate funds for defense, the basic motive is to take advantage of its superiority in some areas and concentrate its human and material resources to achieve military dominance in space. Its main objective is to cause the Soviet Union to suffer economic collapse, to surpass the Soviet Union in technology, and to overwhelm the Soviet Union in military development. Of course, this cannot be tolerated by the Soviet Union.

Future Prospects

The "Star Wars" plan is by no means an accident; it is the inevitable culmination of development and competition in missile technologies and anti-missile technologies between the two superpowers. Its announcement and the subsequent new round of competition in space will result in qualitative changes in the arms race between the two superpowers. The primary changes are: (1) the goals of anti-missile weapons have shifted from point defense (or regional defense) to nationals defense or even multi-national defense; (2) the defense strategy has shifted from a simple, isolated system to a complex, multi-stage system; (3) the struggle for space has shifted from the near-earth region to outer space; (4) the simple offensive and defensive systems have changed to a space-based system using directed-energy weapons for both offense and defense; (5) the weapon systems have changed from expendable weapons with large kill power to a new generation of reusable strategic weapons which are designed primarily for destroying large numbers of enemy targets in a very short time with little or no power for killing human lives. These changes will necessarily lead to new developments in strategic concept and in new theories and tactics for conducting warfare.

One may ask if the seemingly omnipotent "Star Wars" plan conceived by its designers can actually be realized? Although it is still too early to answer this question, some preliminary observations can be made based on the history of Soviet and U.S. strategic weapons development after the war and based on the current levels of technology.

First, the United States does not have a patent on "Star Wars." On 28 January 1985, the Soviet physicist Nikolayi Basov, director of the largest Soviet institute in laser and fusion research and a Nobel prize winner, stated that there is no basic technical difficulty for the Soviet Union to catch up with the United States' "Star Wars" plan. He stressed: "There is no scientific difficulty in developing a laser intercept system in space." This indicated that both the United States and the Soviet Union have the technologies to develop such a system. Furthermore, the current levels of technology on both sides are very close.

Second, the "Star Wars" plan has many weak points. Not only many technical difficulties must still be resolved, the cost is huge (24.7 billion dollars is planned for feasibility studies through FY 1989, and the total investment will be several hundred billion or even 1 trillion dollars), and there are many opponents both at home and abroad (Australia and France refused to take part in this plan), but more importantly, since the system assumes a probability of intercept of close to 100 percent in order to destroy all the incoming missiles, hundreds of sensors and weapons must be deployed in space. At the present time, both the United States and the Soviet Union have a full account of the other side's space vehicles; hence it is technically not difficult to destroy, or at least to deactivate the sensors so that the "Star Wars" plan will be paralyzed. A working group consisting of Soviet anti-nuclear scientists has concluded from their investigations that the "Star Wars" system can be made totally ineffective by weapons which would cost only 1-2 percent the amount of developing the "Star Wars" system. Specifically, by deploying "space bombs" in the vicinity of the "Star Wars" space station, it is possible to destroy the system before it has an opportunity to initiate defensive attacks. Clearly, it is not difficult to detonate either nuclear or non-nuclear devices deployed in space; and there is no warning time.

Third, the Soviet Union is not likely to stand still. On 4 May 1985, the Soviet Defense Minister Sokolov warned: "If the United States destroys the strategic balance of power by militarizing space, the Soviet Union has no choice but to take counter measures in order to restore balance." Reportedly the Soviet Union may deploy bombs in orbit next to the U.S. satellites. Such devices will be orbiting the earth and remain totally harmless, but upon receiving command from the ground, they will detonate and destroy themselves as well as the target.

In summary, the probability of realizing a system which can destroy nearly 100 percent of the attacking warheads and space vehicles as suggested by the "Star Wars" designers is very small; however, the probability of partial realization is quite large. In the future, both sides will continue to struggle for dominance in space, and will continue to deploy new weapon systems including kinetic-energy, laser, particle-beam or even nuclear weapons. The new arms race in space will not cause strategic nuclear weapons to disappear on earth; it will only provide a new territory for nuclear strategic competition on a larger, newer scale. In the foreseeable future, the strategic balance between the two countries including space is not likely to be broken.

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NATIONAL DEVELOPMENTS

VICE MINISTER REVIEWS ELECTRONICS INDUSTRY

OW041221 Beijing Domestic Service in Mandarin 0630 GMT 2 Mar 86

[Recorded talk by Zhang Zuedong, Vice Minister of the Electronics Industry, entitled "China's Vigorously Developing Electronics Industry"]

[Excerpts] Comrades, the electronics industry is a newly-emerging one, to which the people all over China have shown a great deal of interest. Today, I would like to brief the large numbers of listeners across the country on the rapid progress achieved by the electronics industry during the Sixth 5-Year Plan, its fighting goals and guiding ideology for the Seventh 5-Year Plan, and the major tasks for 1986.

1. Rapid Progress Scored During the Sixth 5-Year Plan

Earnestly implementing the party's line, principles, and policies, leading cadres at all levels and the vast numbers of staff and workers in the electronics industry departments worked hard and concertedly in line with the ministry party group's fighting goals and general requirements, which called for laying sound foundations, raising the level, improving the quality, stressing efficiency, octupling [fan san fan] the output value, and prefulfilling the goal by 10 years [chao shi nian], in a reformative and enterprising spirit during the Sixth 5-Year Plan, thereby fulfilling the targets of total industrial output value and profits set in the Sixth 5-Year Plan by two years, opening up a new situation in the electronics industry characterized by sustained, steady, balanced, and vigorous development, and bringing about a breakthrough, as well as penetrating changes, in many fields.

The output and efficiency increased simultaneously. All major economic indexes reached an all-time high. In 1985, the industry's total output value was 28.6 billion yuan, doubling the figure set in the Sixth 5-Year Plan, an increase of about 180 percent over 1980. The annual growth rate during the five years averaged 23.3 percent. (?Taxes) delivered in 1985 totalled 4 billion yuan, up 186 percent from 1980. Annual labor productivity was 19,318 yuan per person, more than double that of 1980, and the profit and tax rate of investment was 25.5 percent. Achievements were also made in both technological transformation of old enterprises and construction of key projects, which have reinforced our material and technical foundations. One third of the key enterprises carried out technological transformation of various kinds. A total of 22 large and medium-sized key projects, including color kinescopes, advanced integrated circuits, computers, and major machinery parts and components, were successively completed and put into operation.

In order to meet the growing market demand, the output of consumer electronics goods increased by big margins during the Sixth 5-Year Plan. Over 40 million TV sets were manufactured during the five years, topping the Fifth 5-Year Plan more than sevenfold. Of this figure, color TV sets totalled 5.7 million. The industry turned out a total of 25 million cassette tape recorders, twenty two fold over increase, and more than 100 million radios, up 45 percent from the Fifth 5-Year Plan.

In short, fairly large progress was achieved in various fields of the electronics industry during the Sixth 5-Year Plan, which has not only contributed to promoting the modernization drive, raising economic efficiency and social benefit, prospering the market, and enriching the people's material and cultural life, but has created sound foundations and conditions for carrying out the Seventh 5-Year Plan.

2. The Fighting Goals and Guiding Ideology During the Seventh 5-Year Plan

The general objective for developing the electronics industry during the Seventh 5-Year Plan is to carry out extensive cooperation and services in the light of the needs of the whole industry, the four modernizations drive, and the new technological revolution, and to concentrate all forces on making strategic changes in the following two fields: Changing the focus of the industry to serve the needs of the national economy, the modernization drive, and the whole social life, and changing the direction of development to making micro-electronic technology the foundation of, and computers and communications the major fields in, the industry.

3. The Jamor Tasks for 1986

As 1986 is the first year of the Seventh 5-Year Plan, this year's work is of great importance in the development of the Seventh 5-Year Plan and the overall reform situation. It is necessary to strive to win the first campaign.

The electronics industry faces broad prospects as well as a heavy task. We are convinced that, under the leadership of the party Central Committee and the State Council, and through joint efforts by all staff and workers in the industry, we shall definitely be able to create a new situation in bringing about a vigorous growth in China's electronics industry and make our contribution to realizing the general task and objective set by the 12th CPC National Congress.

This is the end of my talk. Thank you very much.

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SCIENCE, TECHNOLOGY ASSOCIATION OUTLINES PLAN

OW180043 Beijing XINHUA Domestic Service in Chinese 1130 GMT 17 Feb 86

[By reporter Zhang Jimin]

[Excerpts] Beijing, 17 Feb (XINHUA)--The China Association for Science and Technology held a meeting of its standing committee today, and decided that, in carrying out this year's work, the association would focus on the strategic points for developing science and technology included in the state's Seventh 5-Year Plan, and effectively organize and mobilize the large numbers of scientific and technical personnel in making new contributions to China's scientific and technological progress and economic and social development.

Following are the focal points for this year's work:

1. Actively promote reform among the societies affiliated to the association, in order to build up their capabilities to serve economic development. Societies at all levels should base themselves on the practical needs of the national and local economic development in organizing comprehensive academic activities in a planned manner. It is necessary to support and encourage the societies to promote appraisal and commendation of outstanding theses in order to stimulate scientific and technological progress. The association has decided to set up an annual meeting system, beginning in 1987, and hold a large comprehensive meeting to discuss major topics of economic and social development annually.

2. Conduct in-depth work to popularize science and technology, focusing on invigorating the local economy. Associations for science and technology in all localities should strive to promote the study and development of crop cultivation, aquiculture, and applied technologies for village and township enterprises.

3. Strive to train scientific and technical reserve forces with ideals and innovative spirit. While unfolding various extracurricular scientific and technological activities for youngsters this year, special attention should be given to the third national children's invention contest, scheduled for this summer.

4. Step up people-to-people scientific and technological exchanges with foreign countries to stimulate science and technology and prosper China's economy. Special emphases should be given to academic exchanges in new scientific subjects or alternate subjects [jiao cha xue ke 0074 0643 1331 4430] conducive to the economic and technological development of China and to international academic meetings to be sponsored by our country.

5. Make adequate preparations for the association's third national congress to be convened this year.

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GOALS STATED FOR FUTURE BEIJING S&T DEVELOPMENT

Beijing BEIJING KEJIBAO in Chinese 22 Jan 86 p 1

[Report by Chen Zhiqiang [7115 1807 1730]: "The Primary Scientific and Technical Mission of This City in the `Seventh 5-Year Plan'"]

[Text] During the "Seventh 5-Year Plan," at the same time that this city carries out a penetrating restructuring of its science and technology system, it will adopt various ways to vigorously develop the advantages of science and technology in the capital and will provide more scientific and technical achievements that are of a higher standard and that generate better results, all to better raise the scientific and technical level of this city. Recently, at the first summing-up meeting for specialist advising convened by the municipal government, Comrade Lu Yudeng [7120 1342 3397], chairman of the municipal committee standing committee and of the municipal science and technology commission, said all this when he was speaking of the primary scientific and technical mission of this city during the "Seventh 5-Year Plan."

He said that during the "Sixth 5-Year Plan" this city made startling developments in the aspects of science and technology. We obtained 1,765 scientific and technical achievements in all from 1981 through 1984, which was about 2.3 times the number obtained during the "Fifth 5-Year Plan," and 1,390 among them were awarded national or municipal achievement prizes. In 1985, the science and technology front in this city flourished even more, there having been more than 6,300 science research projects arranged in scientific and technical planning at all levels throughout the city. From these there were 2,400 achievements, the majority of which have already served the economic construction and social development of the capital.

Comrade Lu Yudeng pointed out that during the "Seventh 5-Year Plan," we will mobilize scientists and technicians throughout the city to go further in firming up the thinking that "science and technology must cater to economic construction"; we will continue to adopt methods that are a continuous process from research to development to demonstration to dissemination, and in the aspects of microcomputer technology, biological technology, new materials technology, water conservation technology and water resources, energy conservation technology and new energy, urban modernized management, medical treatment and hygiene, vegetable and fruit products, and new products, strains, and breeding for livestock, fowl, and aquatic products, we will develop a number of scientific and technical achievements that have practical value, and that can also constitute production capabilities; at the same time as we import advanced technology from both abroad and internally, we will quicken its assimilation, absorption, and nationalization; we will selectively enhance construction in rising new technologies and rising new industrial bases to make technical preparations for the next 10 years of great development; we will also pay close attention to a number of technologies that can close gaps and make complete systems, technologies that require little investment, short durations, and that have obvious economic results. This will serve to vigorously promote small and medium enterprises and to develop town and township enterprises.

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MAJOR S&T PROJECTS PRODUCE FAVORABLE ECONOMIC RESULTS

Beijing GUANGMING RIBAO in Chinese 19 Jan 86 p 1

[Text] Reporters have learned from the national economic working conference currently in session that 40 major projects included in the "Sixth 5-year Plan" under the responsibility of economic commissions for the dissemination of new technologies have been basically completed. Among them, projects like replacing silver with aluminum in making mirrors, fuel savings for the Jiefang Model B vehicle, and hot processing have been fundamentally spread throughout the country; projects like technology used at oil field stations, fire resistant synthetic fibers, kayaohua [Catalan ?] forge, metallic spray painting, and electric brush plating have been extended to from 70 to 80 percent of the country. Dissemination of these projects has meant clear gains in economic results. According to incomplete statistics from 16 projects, from a national investment of 142 million yuan, during the "6th Five Year Plan" 1.089 billion yuan was either created or its use value was recovered, and there were savings as well of 5 million tons of coal, 480 million kwh of electricity, fuel consumption of 20,000 tons, 91.8 tons of silver, and 60 kg of gold.

According to materials provided by the science and technology office of the National Economic Commission concerning the national economic working conference, for the 40 major new technology projects mentioned above that have been disseminated, 17 projects have had economic results during the "Sixth 5-year Plan" of more than 100 million yuan, 7 have had more than 500 million yuan, as for example where electric brush plating is already in use on 3,000 pieces of power equipment, created or recovered use value is above 700 million yuan, and there have been savings in foreign exchange of more than 55 million U.S. dollars. Hot spray painting technology is in widespread use at more than 600 units throughout the country, which has either created or recovered use value of 1.3 billion yuan. Due to the fact that the new technology in which aluminum replaces silver for mirrors has been fundamentally disseminated throughout all professions, production quantities of aluminum mirrors have reached 1 million square meters, which has saved 60 tons of silver. Aside from this, projects like breeding and cultivating improved varieties of crops, highly efficient and energy conservative electric lighting, a new model combustion fuel and gas nozzle, and low melting point alloy molds have also had rather large economic results.

During the "Seventh 5-year Plan," the goals for science and technology work in the economic commissions will be to improve the economic results for enterprises and to enhance capacities for export and for creating foreign exchange. Focus will be on dissemination of science and technology achievements in five areas: promoting development of agriculture, forestry, animal husbandry, by-products, and fishing, as well as relevant technologies; developing key technologies for energy, transportation, posts and telecommunications, and raw materials; rising new technologies that center on microprocessor utilization; new technologies that raise the capacities of machine and electronic products to be exported and to create foreign exchange; and advanced technologies that will have a great effect on improving and enriching the standards of the material and cultural life of the people.

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RECENT SUCCESSES FOR S&T INTEGRATION WITH PRODUCTION

Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 14 Feb 86 p 1

[Report by Chen Zujia [7115 4371 3946]: "Integration of Science Research with Production is Unprecedentedly Dynamic"]

[Text] In 1985, China's restructuring of its science and technology system gradually unfolded, taking decisive steps forward. Practice has shown that the direction of the restructuring of the science and technology system is correct, that progress has been healthy, and that scientific and technical work has begun to appear unprecedentedly dynamic as it caters to economic construction.

The other day responsible persons in the State Science and Technology System told reporters that the goal of this restructuring was to release production forces and promote the economy. Accelerating the integration of science and technology with the economy has also become a central problem for the science and technology reform. During this year, the nation will focus on this problem and will adopt a series of measures in the areas of restructuring management methods for allocating science and technology funding, opening up technology markets, promoting the integration of science research with production, strengthening the technical absorption and capacities for development of enterprises, and restructuring the specialist and technical cadre management system, and initial results have already been had. In the face of actual practice, some comrades who had formerly not realized the importance of this integration of science research with production have come to change their views, and awareness within scientific and technical circles has become unified. This has been the best outcome from the year of reform of the science and technology system.

These persons of responsibility spoke of the changes the restructuring had brought to science and technology.

The science and technology markets have sprung up vigorously. That technical achievements are products has become universally understood. Technical products are flooding the technology markets from the coast to the border areas, from the cities to the villages. Even though development of the markets was affected by factors such as money being tight last year, there were difficulties getting loans, and some technical achievements could not be adapted to the marketplace, by the end of 1985 however, the volume of deals implemented at national technology markets had reached 1.77 billion yuan. Technical achievements passed through circulation to enter production, generating economic and social results that are hard to estimate. For certain enterprises, and especially small and medium enterprises and town and township enterprises, it was like a nourishing rain on grain fields, there was an infusion of vitality, and the crop matured to be strong.

A large number of important scientific and technical achievements were awarded prizes. Last year there were 10,476 important scientific and technical achievements awarded prizes after evaluation by the provinces, autonomous regions, directly administered municipalities, and various ministries of the State Council, while in the first 4 years of the "Sixth 5-Year Plan" the annual average number of scientific and technical achievements awarded prizes within the scope just mentioned was only 5,631. In addition, there were in all 185 scientific and technical achievements awarded national prizes of invention last year by the State Science and Technology Commission, as well as 1,772 national science and technology advancement prizes the first time that this has been authorized. The total direct results from these projects are approximately 33.4 billion yuan.

Research, education, production, and joint organizations of various forms have come into being, and are just unfolding. Just on the basis of last year's statistics, there were nearly 10,000 joint organizations of various sorts throughout the country. There have been new trends especially from the point of view of the formats and content of these joinings: they have developed from single project technical cooperation to the development of entire sets of technology; they have developed from limited, loose integration to long term, fixed integration; they have developed from single disciplines and specialties to the inter-regional and interdisciplinary.

Movement of scientific and technical talent has become reasonable. According to a statistical sampling at the end of last year by the State Science and Technology Commission, in 1985 more than 3,000 specialists moved from major cities, more than 1,600 moved from small and medium cities, and more than 1,200 moved into county and town and township enterprises. Although the numbers are rather small, this shows that movement of talent is gradually becoming reasonable. When scientists and technicians move into units and regions that lack talent, this promotes intellectual exchange and the integration of science and technology with the economy.

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CHINA ACHIEVES SUCCESS IN WORLD S&T MARKETS

Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 15 Dec 85 p 4

[Text] Reporters have learned from the National Science Commission that a certain amount of advanced technology embodying the wisdom of Chinese scientists and technicians has become commercial products that have entered the international marketplace.

Not long ago, at the second Barclay Technology Market Exhibition held in Birmingham, England, the 29 technical achievements taken there by the Chinese delegation made up of units from the National Science Commission elicited great interest on the part of specialists and agents from many countries. In only 4 days, agreements and letters of intent were signed for 13 projects. Among them, the United States, England, and West Germany signed contractual agreements for technical rights to a "new method for producing citric acid" researched successfully by the Huadong Chemical Engineering Academy. Among agreements signed with England, there will be annual net profits to our side of more than 500,000 English pounds. The Barclay Bank has indicated that they are willing to provide loans for any Chinese deal, and many intermediary organizations have expressed to us a willingness to act as our representatives for technology trade outside China. The United States, France, and England have also invited us to participate in their technology trade fairs next year.

Relevant personnel in the National Science Commission said to reporters that at the same as we further improve and develop our domestic technology markets, the National Science Commission will consider the arranging of technology exports to be a major task from now on. Next year, in addition to participation in the invention exhibitions in Geneva, Switzerland and in Canada, we tentatively plan to participate in technology trade activities held by Japan, the United States, and England in March, May and November, respectively.

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RESULTS OF MAJOR PROJECTS HAVE POSITIVE IMPACT ON PRODUCTION

Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 1 Jan 86 p 3

[Text] During the period of the "Sixth 5-year Plan," 20 major basic research projects arranged by the State Economic Commission scored great successes: some basic theoretical research has already reached a nationally advanced level; after a number of basic research achievements were used in production efforts, they brought in remarkable economic results.

To allow science research to reach disposition in depth, as well as to allow basic research to develop in a stable, continuing way, during the period of the "Sixth 5-year Plan," the State Economic Commission focussed on 20 basic and applied basic research projects in mathematics, physics, chemistry, mechanics, biology, chemical engineering, engineering thermodynamics, and materials science. They also broke through divisive limitations and selected special units throughout the country, organizing them into carrying on joint research without regard to departments. There were altogether more than 90 units from 20 departments that took up the research duties for these projects. The majority of this group of research projects proceeded from the characteristics of disciplines, and were proposed in consideration of problems in our economic construction that needed solving in aspects of energy, natural resources, materials, environmental protection, biological technology, and precision engineering. During the work process, not only did they not relax the exploration of questions of fundamental theory, but also were careful to use scholastic achievements promptly in production. In aerodynamic research at Huazhong Engineering Academy involving the combustion process, through experiments with water simulation, aerodynamic simulation, and hot-start simulation, they developed for the first time in China a new technology for an odd-shaped particles stablizing combustor, which allows the powdered coal boilers of generating plants to reliably burn inferior coal, as well as to be able to save on combustion fuel. The results from its test use by only 44 boilers in 29 generating plants are annual savings in expenses of more than 50 million yuan. According to incomplete statistics, after results from these 20 major basic research projects were used in actual production, economic results so gained have been more than 200 million yuan, which is several times more than the economic invertment in these projects. The economic results that can be obtained from seven projects among them, Xi'an College of Communications' "Researches Into Pipeline System Vibration," are above 10 million yuan.

The State Economic Commission has made the necessary arrangements in these 20 major research projects for those that cannot directly show economic results but are basic research of a higher caliber and of a high scholastic level.

As work develops in these major basic research projects, relevant departments and units will have correspondingly built and enriched a number of laboratories, making them into a base for basic research that is special to this country, where basic science research contingents will have obtained stability and development and will have fostered and trained a number of scientists and technicians of a high level, and where much outstanding talent will have emerged.

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NUMERICALLY CONTROLLED MILLER SUCCESSFULLY MANUFACTURED

Beijing JINGJI RIBAO in Chinese 29 Jan 86 p 2

[Article by Qing You [7230 2589]: "Numerically controlled Millers up to the Standards of the 1980's Successfully Manufactured in China"]

[Text] Two types of advanced numerically controlled machine tools to be used in the design and manufacture of aircraft parts, namely, the three-coordinate numerically controlled miller and the five-coordinate numerically controlled miller, were successfully manufactured by the aeronautic technological research institute of the Ministry of Astronautics not long ago.

With the aid of electronic computers in design, these numerically controlled millers, which are up to the standards of the 1980's, can help shorten the trial manufacture period of airplanes with very remarkable economic results. As we understand, when the five-coordinate numerically controlled miller manufactured by this institute was used to process a new type of aircraft part of the Shenyang Aircraft Plant, the trial manufacture period was reduced by 6 months with a saving of 122 steps and 2 million yuan. The machine tools of this kind, formerly produced in small quantities, were only up to the international standards of the 1960's in terms of technology and performance. They were inadequate for our requirements, and only a few countries in the world could produce them. To reduce the gap between the Chinese and the international standards in the technology of designing and manufacturing aircraft, the problem of modernizing the production equipment was in urgent need of solution. On the basis of full investigation and appraisal, this research institute studied the similar equipment of other countries, and then supplied reliable data for the trial manufacture of prototype airplanes.

On the question of importing advanced equipment from abroad, this institute was of the opinion that the basic way to reduce the gap was to raise our own standards, since sole reliance on the purchase of equipment would still fail to accomplish this purpose. The main goal of importing technology should be to strengthen our self reliance. Therefore, the institute made full use its technical resources in the comprehensive and in-depth analysis and assimilation of the advanced foreign technology from the time when it first assembled the parts imported as bulk cargoes, and then replaced them with more and more domestically produced components and raw materials. Through the efforts in various quarters, it was able to begin the manufacture of its own prototype airplane and the small-scale production of components and raw materials in only 4 years. At present, 30 out of the 48 parts in the machine tool are produced in China. A total of 139 types of materials and 150 sets of components, 70 percent of the grand total of materials and components, are now being used. The numerically controlled machine tools made of domestically-produced components and raw materials are up to the standards of similar numerically controlled machine tools of foreign countries, and the computer technology has reached the standards of the early 1980's. This not only marks a new development of China's technology in the manufacture of machine tools, but also reduces the time-lag between China and the foreign countries in the technology of manufacturing advanced products by more than 10 years. Because of its mastery of advanced technologies, this institute has also trial manufactured a four-coordinate numerically controlled miller urgently needed for the production of helicopter parts.

This institute has now received orders from the major aeronautic plants for 16 sets of equipment to be used entirely for research in manufacturing new airplanes. If all these sets are purchased from foreign countries, we will not only fail to learn any new technology or to improve the technology of producing machine tools, but also have to spend more than $10 million. Now that China is able to manufacture these machine tools, its expenditures in technical transformation alone will be reduced by 12 million. The value would be even greater if the economic results in production are also taken into account. The successful manufacture of this machine tool will not only meet the requirements of China's aeronautical industry for the next 10 years, but also set a good example for the proper handling of imports.

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CONFERENCE ON COMBINING RESEARCH, PRODUCTION HELD IN DALIAN

Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 17 Dec 85 p 4

[Article by Ruan Bingsen [7086 4426 2773] and Chen Zujia [7115 4371 3946]: "Fang Yi Stresses Strengthening of Joint Groups for Science Research and Production"]

[Text] Member of the CPC Central Committee Political Bureau Fang Yi pointed out on 16 December that we must further develop and enhance the integration of science research and production in all forms. Fang Yi said that the party Central Committee and State Council had evaluated highly the development of joint forms of science research and production. When he was evaluating the significance and functions of these kinds of integration he felt that having many types of integrated research and production is an important form of organization for strengthening the integration of science and technology with the economy, and is an effective blow against divisions between areas and problems with departments. He also felt that it is an effective path toward strengthening the capacities of large enterprises for technology exploitation and absorption.

Fang Yi said this as the National Conference for the Exchange of Experiences Regarding the Joining of Research and Production was concluding. In his speech he analyzed the current situation regarding restructuring of the science and technology system. He said that reform of the science and technology system has already become one of the important matters in China's restructuring, and had become a major item in the eyes of the whole party and of the people of the nation. The nation has determined that during the "Seventh 5-Year Plan" it will correspondingly increase science and technology funds. The technology markets have developed greatly. Various forms of joint arrangements of research, education, and production are in the ascendant. The scientists and technicians technical vocation hiring system is spreading everywhere. The National Natural Science Fund Commission is just now deliberating. Science and technology legislation and science and technology statistical work is just now intensifying. Progress in the establishment of science and technology credit and risk investment has had a good beginning. To allow for stable forward progress in reform of the science and technology system requires that we strive over a long period.

As Fang Yi was talking of the major tasking during the "seventh 5-year plan," he stressed that restructuring the science and technology system was not only an affair of the science and technology departments but is also a matter for departments concerned with planning, economics, finance, taxation, education, labor, and legislation. All relevant departments in the nation must be diligent in making their own contributions to promoting the restructuring of the science and technology system.

The National Conference for the Exchange of Experiences Regarding the Joining of Research and Production held in Dalian concluded on 16 December. Song Lian, deputy director of the State Council science and technology leading group, handled the closing ceremonies and also spoke.

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EFFECTS OF RISING NUMBER OF INTEGRATED OPERATIONS NOTED

Shijiazhuang HEBEI RIBAO in Chinese 21 Dec 85 p 1

[Text] As the restructuring of the science and technology system has unfolded, research and production integrated bodies in this province have grown to more than 1,000. Many integrated bodies are just developing from initial levels to higher ones, from short term to long term, and from loose models to tight ones. These science and production integrated bodies are a new form of technical and economic organization, the important functions of which are more and more evident.

First of all, by promoting the integration of research and production, the time for research achievements to be transformed into production forces is shortened, which is of benefit in unifying research and production. The Tianjin Institute of Electrical Transfer Design of the Ministry of Machinery Industry completed the design of a hot metal detection device in 1982, but restricted by conditions, they had to wait until this year for trial production. After this institute had made a deal with the Baoding Automation Equipment Plant to form a research and production integrated body, they had produced the product in less than 6 months, and it passed technical appraisal.

Second, it is beneficial to developing products of outstanding quality and strengthening the capacities for competition among enterprises. The Instrument Plant in Botou developed jointly with the Shanghai Institute of Automated Instruments a steam flow meter, which was awarded the "Gold Dragon Award" for new products by the State Science and Technology Commission, and which has twice been cited by the State Science and Technology Commission and the Ministry of Machinery Industry as a new product to be disseminated throughout the country.

Third, it is beneficial to the advancement of technology and to the training of talent. Integrated bodies are organic combinations that have different levels and research personnel, engineers, and technicians of different types, which serves to get the most from each in pushing technical advancement. At the same time, the adoption of new technology also promotes study by factory management personnel and technicians and workers, and it improves enterprise management standards and its technical quality. Many enterprises have used the opportunities from having scientists and technicians from colleges and universities and from research units working in their factories to run training classes or technical schools, which has had good results.

Fourth, each aspect of an integrated body can achieve a certain measure of economic results. After the Baxian General Machinery Plant joined with the No 17 and No 207 Research Institutes of the Ministry of Astronautics, they developed large children's play equipment, like traveling missiles and aircraft, which in a relatively short time have had obvious economic results.

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PRINCIPLES FOR IMPORTATION, USE OF TECHNOLOGY SUGGESTED

Beijing GUOJI MAOYI WENTI [INTERNATIONAL TRADE JOURNAL] in Chinese
No 6, 1985 pp 5-10

[Article by Yi Hui [1707 6540], Office of Policy Research, Ministry of Machinery Industries: "Some Thoughts on Suitably Advanced Technology--Important Guiding Ideology for the Importation of Foreign Technology"]

[Text] Use of Advanced Technology is a Scientific Concept

At the same time that we import foreign technology we must oppose two prejudices: one is to ignore our national conditions and one-sidedly seek after the advanced; the other is to ignore the advanced by one-sidedly focusing on the existing base. These two prejudices that actually exist in the work of importing foreign technology are both created through errors in guiding ideology, and if we do not guard against them and pay attention, they will grow into strategic errors.

The prejudice by which people one-sidedly seek after that which is advanced comes from an ignorance of this country's actual situation. People who do this have not correctly recognized the economic and technical situation in this country and its requirements, nor our capacities for absorption and assimilation. This kind of advancement is a blind, abstract advancement where haste makes waste, and which must necessarily lead to the wasting of funds; the prejudice by which people one-sidedly focus on the existing base comes from an evaluation of this country's economic and technical base and capacities that is too low. They cannot see their own advantages, nor the creativity and motivation of people in this country. This naturally leads to following on the heels of foreign countries, blindly following their lead, with never any way to allow China's science and technology and the national economy to leap into the ranks of advanced world levels. Because of this, to analyze correctly and treat our actual national situation in a practical manner is extremely important for establishing a correct guiding ideology for the importation of technology.

The current situation regarding the material technical base in this country is, simply put, that it has been under construction for 35 years, and a material technical base of reasonable scale has already been established, and this constitutes a strong ability for building toward a socialist modernization; but this material technical base and building capacity is still some distance behind advanced countries in the world and from socialist modernizing construction. This situation is specifically apparent in the following aspects:

I. The science and technology system has already been formed, but the quality of science research is somewhat backward. China has formed a science and technology system that is complete in disciplines, where there are more than 430 independent science research organizations at the prefectural and city level throughout the country, with a contingent of 6.85 million scientists and technicians, and where each year there are thousands of research achievements registered with the state by regions and departments. But we must see that because of years of "leftist" ideological guidance, knowledge has been thought lightly of, and striking out against intellectuals became a social phenomenon, and the intelligence and wisdom of scientists and technicians were suppressed. Add to that a long term isolationist policy, and we can see the technical quality and knowledge structures of our scientists and technicians would always lag behind the development of modern science and technology, and could not suit the needs of modernizing construction. Scientific and technical facilities are also rather obsolete and backward, requiring renovation and improvement.

II. Certain high technology fields have leaped into prominence in the world, but the vast majority of technical fields are universally backward. In certain high technology fields, as for example space navigation technology, atomic energy technology, and electronics, China has already entered the world's advanced ranks. Since 1970, we have successfully launched 15 satellites. Among them, long range rockets flew into the Pacific, under the sea submarines have launched solid body carrier rockets, experimental communications satellites have been launched into geosynchronous orbit and successfully located, which shows that China's space technology has already joined the ranks of the world's advanced. The first 100 million operations super computer and the first 10 million operations vector computer successfully built by China indicate that we have attained advanced world status regarding the building of super computers. However, in general industrial technical fields like chemical engineering, metallurgy, and machinery, the scientific research levels, design levels, and technique levels are universally behind advanced world standards. Of the current 400,000 enterprises in this country, only 20 percent have technology and equipment that are advanced, with 30 percent having that of general quality, and about half the enterprises having processing equipment and measurement equipment that is obsolete and in urgent need of replacement.

III. Raw materials and technical equipment are basically sufficient for domestic use, but there are few types of products, quality is deficient, and technical performance is low. The steel products, non-ferrous metals, and materials for chemical engineering that are needed by China's national economy, as well as the technical equipment to equip the national economy, are already basically provided within the country. Taking the machinery industry as an example, the domestic machinery industry has provided 300,000 kw thermal and hydroelectric generating units, 330,000 volt and 500,000 volt output transformer equipment for the power departments; for the metallurgy industry they have provided 30,000 ton drop-forged hydropresses, cold and hot rolling machines for 2400 aluminum slabs, and rolling machines for extra-thick 4200 slabs; for all professions and industries in the country they have provided 130 different kinds of high precision machine tools and more than 40 different numerically controlled machine tools; for agriculture and the national defense they have provided a large batch of technical equipment. According to statistics, of the technical equipment needed by all departments of the national economy, more than 85 percent is provided by the machinery industry. However, the variety, quality, and technical performance of domestic products are still far from satisfying the needs of modernizing construction. Surveys have shown that the varieties of Chinese electro-mechanical products are for the most part still at the world levels of the 1950's and 60's. Only a few approach or reach the levels of the 1970's. Some of the electro-mechanical products of modern standards needed by the national economy are still in short supply; much large and bulky energy consuming equipment is backward in performance, and energy consumption is high; we cannot yet produce many of the high precision, high efficiency machine tools and accurate instruments and meters.

IV. Industries along the coast and in the established industrial bases are somewhat developed, while the vast number of those in the interior are quite backward. Due to historical and geographical reasons, each province and municipality along our coast, as well as some established industrial bases, are also more developed in the areas of science and technology and production capacity. Thirty-five years of construction, and especially the three lines of construction in the early 1960's, have played a positive role in changing this inequality in economic and technical development. Looking from the current overall industrial picture, China has already formed an industrial situation where departments are rather complete, the overall arrangement is reasonable, the standards of installed equipment are steadily improving, and everything is at a fitting scale. Because industrial environments are rather backward in the interior, and especially regarding the industrial base, transportation and shipping, and science instruction in the three line regions, technology and the economy are still behind that of the coastal provinces and municipalities and the established industrial bases. As far as science research organizations and scientific and technical capacities are concerned, they are all quite behind that of the coast and established industrial areas. The majority of new products, new technologies, and new techniques are being developed successfully along the coasts and at established industrial bases.

Beginning from the preceding analysis of the national situation, we naturally come to the concept of suitably advanced technology. This concept not only stresses advancement, but also suitability. By bringing them organically together, we can prevent the two deviations of one-sided seeking out of the advanced and one-sided stressing of existing bases. By suitably advanced technology is meant: technology that has already been replaced in developed countries; technology that is currently being used in developed countries; and a certain portion of new technology that is just now appearing in developed countries. In this way, having technology of all levels in reasonable allocation according to actual need we can impel China's science and technology to catch up with advanced world standards as quickly as possible.

We can see from this that suitably advanced technology is a scientific concept that eliminates one-sidedness. However, it is insufficient to realize only this point. Even more important is that we must establish suitably advanced technology as an important guiding ideology for China's importation of foreign technology.

The Characteristics and Significance of Suitably Advanced Technology

I. Suitably advanced technology is characterized by different levels of technology and reasonable structures, and it can promote the improvement of China's science and technology standards from all aspects.

World science and technology, and especially the history of the development of science and technology in industrially developed countries, have shown that multi-level production forces and multi-level science and technology co-exist, they are the objective process by which production forces develop and science and technology progress, and this is also the situation for China's science and technology. The primary reasons multiple levels of technology co-exist are:

A. Science and technology have strong continuity and inheritance. Today's science and technology have developed from yesterday's science and technology. Continuity and inheritance reflect the internal relations in the development of science and technology, and these internal relations chiefly appear in two aspects: one, a technology will have a developmental process from the discovery of its principles to laboratory research, all the way to industrial application; two, a technology is a process of continuous development from the lowest levels to the highest. But in the developmental process the shape of each stage of development will be retained, which gives rise to differing levels. As for example with production technology equipment, the developmental tendencies are always: from manual labor to semi-mechanization, and mechanization, then from semi-mechanization and mechanization to semi-automation and automation. But actually, even in situations when the level of automation is rather high, semi-mechanization and mechanization cannot be eliminated, and even in certain cases manual labor cannot be done away with.

B. A new technology always breaks though from a particular sector, only after which can it extend to other areas. This extension to other sectors requires a process that is either long or short, which gives rise to conditions in which differing levels of technology appear and co-exist. For example, integrating the mechanics and electronics on technical equipment begins first with metal cutting machine tools. In the early years of the 1950's, in order to process military machine components with complex shaping and high requirements for accuracy, the United States designed and built numerically controlled machine tools. Because there were many advantages to this type of machine tool over regular machine tools, they gradually came to be used in machining for civilian industries. At present, not only have numerically controlled machine tools continued to develop, but advanced technology with integrated mechanics and electronics has come to be applied to much technical equipment. However, whether people are replacing obsolete equipment with new technical equipment or are using new technology to transform existing technical equipment, either takes time and each is a process. Therefore, among the technical equipment currently possessed in China, although that with electromechanical integration has continued to increase, regular technical equipment of different standards is still much in evidence. The process by which this proportion constantly changes is just that process of the dissemination of new technologies.

C. Because of the gaps in technical bases created through history, different areas have different technical levels. China can be seen as having generally three situations: the material technical base is quite strong and the level of technology is quite advanced; there is a certain material technical base and the level of technology is average; the material technical base is rather weak and the level of technology is backward. In this way, and looking at it from the point of view of the entire country, there have come to be technical structures at different levels. There are only a few coastal cities and established industrial bases where the level of technology is comparatively advanced, and the majority of areas still have average levels and backward conditions.

The strategic goals for the development of China's science and technology ought to be to allow science and technology a full scale improvement, so that it may catch up to advanced world standards. Looking at it from one angle, by full scale we mean that the level of science and technology in every sector and area should improve in all aspects; from another point of view is meant that the technology at each level achieve a full scale improvement, and that it take the path of science and technology developing simultaneously at different levels. The concept of suitably advanced technology is just this requirement for simultaneous development at different levels.

The path of simultaneous development at different levels is in accordance with the rules of scientific and technical development and also coincides with our national situation. This is because: 1) Generally speaking, traditional technology is the base upon which traditional technology is universally used, and with no development in traditional technology, new technology would be just castles in the air. Especially for China, where the levels of technology for the vast majority of areas are at a state of average or backward, and even in areas of relative advancement there are still great gaps when compared to foreign countries. This sort of situation means that China's current traditional technology is in a commanding position, while the advanced, and especially the rising new technologies, are very weak. In implementing China's science and technology modernization we must seriously consider and hasten the development of traditional technology. Only in this way can a stable foundation be laid for the development of new technology, and can development funds be provided and accumulated. 2) Development of advanced and rising new technologies also put new vitality into the development of traditional technology. The history of industrial development has told us that constant changes are caused in all industries and all products by the adoption of new technology. The integration of machinery with electronics is the most representative example. Traditional machine processing equipment, when outfitted with computer control, can add features to the equipment, expand its processing scope, improve product quality, improve labor productivity, and lighten the intensity of labor.

II. Suitably advanced technology puts advancement in an extremely important position, one characterized by extraordinary development, and that can quicken the process of China's building toward modernization.

In importing foreign technology, the final goal is to borrow from the experiences of foreign countries, to seldom or never make the mistakes that foreign countries have made, to directly or indirectly use the scientific and technical achievements of foreign countries, to close the gaps with foreign countries as quickly as possible, and to hasten China's modernization, but absolutely never to get into a race with developed nations that maintains a constant lag. This is to say that we want a certain measure of extraordinary development. Because suitably advanced technology has gotten rid of one-sidedness, it has placed advancement into an extremely important position, for which reason, by actively importing suitably advanced technology we can generate the effect of extraordinary development, which will allow the extraordinary existing base of China's science and technology to approach or reach advanced world standards.

The histories of economic and technical development both here and abroad have all shown that countries with backward economies and technologies can exhibit extraordinary progress and can catch up with and surpass economically and technically advanced countries by importing foreign technology. As for example with England, which only by inheriting the science and technology of European mainland countries like Italy, Holland, and France, and making great progress with technologies like the steam engine, steel refining, and weaving, could become the world's leading industrial nation. The industrial revolution in Germany was later than in England and France, but Germany learned from the advanced experience and technology from England, and afterwards reigned supreme, in economic power exceeding that of England. The United States made use of immigrants from Europe, learned European technology, and made new breakthroughs in some major scientific and technical fields, and economically and technically caught up with and surpassed the industrially developed nations of Europe. After the Second World War, the example of the economic and technical development of Japan is even better able to elucidate the problem. As the Second World War concluded, Japanese industry was on the brink of paralysis, and the economy fell 20 to 30 years behind that of the European and American developed nations. Beginning in the 1950's, Japan imported foreign technology on a large scale, gathering together nearly all the technical achievements that had been developed in the half century to eventually become one of the major nations with a capitalist economy. According to statistics, by actively importing technology, in the process of catching up to and surpassing advanced world levels they saved approximately two-thirds of the time and 90 percent of the research funds. By the end of the 1960's, levels of technology in the industrial sectors of steel, ship building, vehicles, petroleum engineering, synthetic chemical fibers, and household appliances, had either reached or surpassed the European and American developed capitalist countries in less than 20 years, and had fundamentally turned around a technically backward situation. In recent years the pace at which China has imported advanced technology has already quickened, as for example in the Ministry of Machinery Industries system, which in the nearly 7 year period from 1978 to 1984 imported more than 500 technologies, a sizeable portion of which have already been assimilated and mastered and have put been into industrial production. Importing technology has had a positive effect on technical progress in the machinery industries, winning for China 10 or 20 years time in catching up to international advanced standards in these technical fields, and obtaining rather good economic results.

Suitably advanced technology puts advancement into an extremely important position, and has a very great significance regarding how China is to correctly deal with the new world technical revolution. We are faced with a new world technical revolution that is developing rapidly, and for us this is both a challenge and an opportunity, for how to meet the challenge and utilize the opportunities is directly related to the larger problem of quickening the construction of socialist modernization. Beginning from this concept of suitably advanced technology, we can very naturally consider the importation of new technology as part of the importation of technology. In some new technical fields we can then begin from the same starting line as developed countries; proceeding from China's actual requirements and capacity for assimilation and absorption, we are in urgent need of developing and establishing new technical professions in China, especially to use new technologies to transform our traditional industries.

III. Suitably advanced technology is characterized by its fast transformation into production forces, and it can give full play to economic results as quickly as possible, and can accumulate funds for the state.

In importing technology, the important thing is to import technical materials and blueprints that embody research, design, and technical methods. This kind of technology in its intellectual state must be transformed before it can become actual production forces. Even if together with importing technology processing equipment and testing equipment is purchased at the same time, only after technology in an intellectual state has been transformed can it actually function as a productive force.

The final goal for the importation of technology is to develop China's production forces. Therefore, assimilation and complete understanding allows imported technology to be quickly transformed into productive forces, and is thus a key to the importation of technology. There are examples of this both in this country and abroad, where after a technology has been imported it cannot be assimilated and completely understood even after a long time, it cannot quickly be transformed into a productive force to provide products for society, and if people wait until it can provide products for society, the next generation of foreign technology has already entered the marketplace. This then loses the real significance of importing the technology, creates a great waste of the nation's funds, and gives rise to vicious cycles in the importation of technology. One of the main reasons for appearance of this sort of phenomenon is that suitably advanced technology had not been the guiding ideology behind the importation of technology.

The fundamental requirements for suitably advanced technology are that it take the national situation into full consideration, that it proceed from the actual technical base and support of the local department, the local region, and the importing unit, and their capacity for assimilation and absorption.

It must also eliminate the two one-sided tendencies of over emphasizing advancement and neglecting suitability, and one-sidedly stressing the base while neglecting advancement. Suitably advanced technology imported according to these basic requirements can quickly be transformed into production forces, and very quickly to develop economic results so that the state might accumulate funds.

The facts about China's importation of technology over the past few years have shown that whenever the guiding ideology is correct and suitably advanced technology is imported, then results are good; on the other hand, when this guiding ideology is violated, the results are not good. For example, the Hangzhou Oxygen-Producing Machinery Plant is a key enterprise in China's oxygen producing machinery business, with over 20 years experience in manufacturing large-scale oxygen-producing machinery. But because its design and manufacturing technology was backward, the standards of its products were always less than the international standard. To change this backward situation, this plant imported the complete manufacturing technology for 10,000 cubic meter oxygen producing machinery from the Linde Company of West Germany, signed an agreement for cooperative production, and in less than 4 years had absorbed and mastered the international technology. Then, drawing inferences from what they had learned, they applied advanced technology to oxygen producing machines of various specifications. They used the new technology to manufacture two oxygen producing machines for the Baoshan Steel Mill and the Jinshan Petroleum and Chemical Engineering Main Plant, the technical performance of which is equal to the level of similar international products. Comparing these to the old products of this plant, where the former ones could be in continuous use for 8 or 9 months, that was increased to one year and more. The 0.72 kwh of power needed to produce 1 cubic meter of oxygen was lowered to 0.52, so that a 10,000 cubic meter oxygen producing machine operating for 1 day could save 48,000 kwh of electricity. And another example. The Shenyang Water Pump Factory is an established water pump factory that imported the water pump manufacturing technology for power station boiler use from the West German KSB Company, and went into cooperative manufacture with the foreign company. After assimilating and mastering foreign technology in only 2 years time they were able to produce a boiler use water pump for a 300,000 kw generator set. This saved at least 10 years from the process of designing it from scratch themselves.

Principles for the Selection of Suitably Advanced Technology

Since suitably advanced technology is this important for China's scientific and technical progress and for quickening the construction of socialist modernization, as we import technology, we must earnestly and self-consciously select suitably advanced technology. From the point of view of current and future scientific and technical development, we should abide by the following principles when selecting suitably advanced technology:

I. The principle of economic reasonableness and economic results.

We should make two comparisons: one is a comparison between the two methods of self design and importing technology. As to whether a technology is to be self designed or to be imported from abroad, we should see which method would save the most money and also be fastest at obtaining new technology. To import technology from abroad that is already mature is certainly a shortcut to accelerating the progress of China's technology, but it should not eliminate reliance on self design in certain aspects to obtain results that are better than from importing the technology. This is to say that if we do serious feasibility studies and compare the programs, we cannot say that in all cases everything should be imported from abroad. If it is technology and equipment urgently needed by the state, it will be much more expensive to import the technology than to make it ourselves, but much time could be saved. In this situation, money must yield to time in order to meet national exigencies.

II. A comparison of the money spent to import a technology with the economic income generated after importation of the technology.

If we are to gain the most economic earnings from the least expenditure for importation, we must evaluate the economic results of the importing unit and society's economic results. Much imported technology can advance an enterprise's design and manufacturing technique, can improve production efficiency, and consequently can improve the economic results of the unit importing the technology; the products produced when the unit importing the technology uses the new technology have the advantages of good performance and high quality, and they also will have improved the economic results of the units using the products, and will therefore have improved the economic results for society. This is of course the most ideal. But it often happens that the economic results for the unit importing the technology are not particularly outstanding, while those of society are. This then requires us when comparing the two situations to join the economic results of the unit importing the technology together with the economic results of society. Whenever the economic results of society are clear, while the unit importing the technology cannot realize a greater economic gain, or cannot realize a gain at all, the state should subsidize this effort.

III. The principle whereby importing technology will transform the existing industrial base.

This principle is the same as building the national economy by focusing on internal expansion and reproduction. The outstanding contradictions existing universally in our industry are: 1) Science research is backward. This is primarily apparent in our incomplete science research facilities, where methods are obsolete, where new products are slow to develop, and where there are difficulties in product renewal. 2) Design is backward. This manifests itself primarily in backward design thinking, backward design methods, and backward means of design. Consequently, this leads to products being insufficient before they begin and to long lasting design periods. 3) Techniques are backward. This is apparent for the most part in continued use of many techniques and methods that are no longer used abroad, which gives rise to low productivity, high expenditure, and product performance and quality that cannot be guaranteed. 4) Management is backward. This shows itself in backward management methods and management means, which lead to management confusion and affects economic results. If we can change the backward situations in the areas described above, they ought to become the focus of the importation of technology, while if this point is well taken care of, things will well embody the principle of being suitably advanced.

IV. The principle of importing the newest technology in a planned and focussed way and of developing China's rising new technical professions.

Developing China's rising new technical professions is for the most part a two part subject: 1) As quickly as possible we must establish new domestic professions. As for example with electronics, which whether it is a matter of improving products or techniques or improving management, in neither case can we fail to use computers, especially microcomputers, because we are currently facing the great mission of technically renovating our existing industrial base. From now on, there will be a great need by each sector of the economy for computers. Therefore, we must establish an advanced Chinese computer profession by importing technology. Or another example, new types of materials. With the rapid growth of this country's steel products, we are restricted by coal mining and electric power, while with future development of our energy resources we will be hard pressed to satisfy the needs of the development of our national economy. Because of this, we should develop as quickly as possible new types of materials that consume less energy, which is an important means by which to resolve insufficient provision of raw materials. 2) Some new technologies are less restricted by traditional technology, and we can keep pace with the foreign industrially developed nations. Of course, this kind of new technology must be selectively carried out, and we must begin with fields that require little investment, and cannot just fully spread out without regard to national capabilities.

By developing rising new technical professions we can generate direct results of surpassing development that can in some areas serve to guide traditional industries through the surpassing development of technical transformation.

V. The principle of combining transfer of the rights to foreign technology with transfer of the rights to domestic technology.

That we import foreign technology is because we are not on an equal footing with foreign scientific and technical development, especially where China's science and technology universally lag behind that of developed nations. As we have said above, the degrees to which China's domestic science and technology are developing are not equal, since interior areas generally lag behind the coastal areas and established industrial bases. Because of this, at the same time that we pay close attention to transfer of the rights to foreign technology, we should also be aware of transferring domestic technology, for backward areas should actively import technology from the coastal regions. If we work in this way, it will be beneficial both to the state and to enterprises. Another aspect to transfer of domestic technology is that civilian industries will actively import technology from the national defense industries. Because of the results from major national investments, in many aspects the national defense industries are more advanced than the civilian ones, and many technologies that have been long time stumbling blocks for civilian industries have been successfully dealt with for some time by the national defense industries. Therefore, we should break through the sectoral blockades and barriers between national defense industries and civilian industries as quickly as possible, and should broadly open up scientific and technical exchanges between the national defense industries and civilian industries. Relevant departments ought to open up channels for the import of advanced technology from the national defense industries by the civilian industries, and encourage and support technical exchanges between these two sectors.

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SCIENCE FUNDING SYSTEM BENEFITS BASIC RESEARCH

Beijing GUANGMING RIBAO in Chinese 27 Dec 85 p 1

[Article by Wen Zhenshun [3306 2182 7311]: "Implementing the Science Fund System Benefits Basic Research"]

[Text] Implementing the science fund system is beneficial to support of fundamental work (basic research, hereafter) in basic research and applications research. This was the initial experience out of the summation of the fourth conference held by the Science Fund Commission of the Chinese Academy of Sciences on 26 December.

The Chinese Academy of Sciences Science Fund is a national natural sciences fund established with the approval of the State Council in 1982.

In the past 4 years, the science fund commission has granted financial aid to 4,424 projects, the total of subsidies has been 172 million yuan, divided approximately among 47 percent of the projects applied for and for 23 percent of the funds requested.

It is the belief of this commission that the primary strengths of the science fund system are: 1) that it can provide a reliable guarantee of funds for the stable development of basic research; 2) that it will aid in improving the results from science research investment; 3) that it enhances the feelings of responsibility among scientific researchers; 4) that it can promote competition in basic research, and can provide even more opportunities for the maturing of young researchers and for outstanding talent to emerge; 5) that it can accelerate cooperative research among researchers in different disciplines and from different units and the exchange and permeation of scholastic thinking, as well as the reasonable movement of scientific researchers; 6) that it will be beneficial in giving full play to the advisory roles of specialists in the decision making process for science research management, avoiding inappropriate administrative interference. However, there are still problems with the science fund system. Comrades participating in the conference gave their suggestions for improving the science fund system.

Lu Jiaxi [4151 0857 6932], chairman of the Science Fund Commission, participated in the conference, which was chaired by deputy directors Yan Dongsheng [0917 2639 3932] and Xie Xide [6200 1585 1795].

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RESTRUCTURING OF S&T SYSTEM BRINGS GOOD RESULTS

Shijiazhuang HEBEI RIBAO in Chinese 7 Jan 86 p 1

[Text] Through thorough implementation of the resolution by the CPC Central Committee regarding restructuring of the science and technology system, last year 86 of the 138 research units in this province put the institute director responsibility system into effect, 96 implemented the topic contract system, taking responsibility for a total of 1,529 research topics, a 42 percent increase over last year; 479 achievements were disseminated, which is 29 percent more than last year; net income from technology reached 1.05 million yuan, which is up 40 percent over last year. Twenty-two of the 61 development research units have economic independence, and 30 of the others have reduced operating expenses by 1.78 million yuan.

Expanding the autonomy of research institutes, and using "without restraint" to promote "change."

On the basis of the 1984 readjustment of science research unit leading groups, this province last year expanded the autonomy of research institutes. Based on a survey of 120 science research units, 91 units have tasking authority for readjustment of direction, 97 units have science research planning authority, 96 units have authority for fund utilization, 104 units have organization creation authority, 98 units have the authority to transfer the rights to technology, and 66 have management authority over personnel affairs. This is the premise and basic condition for smooth operation of the restructuring.

Restructuring allocation management methods for operating expenses, giving full play to the promotional function of economic levers on the restructuring.

The provincial science and technology commission has required that development research units gradually reduce operating expenses and that other research units practice operating expenses responsibility. They have also worked out corresponding methods of reward. Actual practice has shown that by putting these methods into effect, achievements from science research can be quickly transformed into production forces. According to a survey of 61 development research institutes, technical income last year had already reached 7 million yuan. Since the Tangshan Electromechanics Research Institute became a restructuring experimental site in 1984, of the 54 science research projects that have been arranged there, 46 have been topics in service of small to medium-sized enterprises.

Models lead the way, promote in-depth development of restructuring.

Summing up and disseminating the experiences of units from the Provincial Microbiology Research Unit and the Shijiazhuang Building Materials Research Institute at provincial science and technology working conferences has put a new prospective on the restructuring of science and research units: one thing has been that it has broken through barriers between regions and departments and has begun to transcend regions and departments to provide services to society; a second thing has been widespread respect for developmental research in appropriate technologies, with attention paid to the dissemination and transfer of achievements and to complete sets of technology; and third has been the great increase in research projects.

The joining of developmental research with production, promoting the transformation of technical achievements into production.

Through the means of organizing technology trade and of combining efforts in tackling key problems, the provincial science and technology commission and relevant departments have acted as go-betweens and links to promote the joining of scientific research with production. As the development of restructuring has deepened, many research units have solicited integration through advertisements and publicity; they have sought integration through technology markets; and they have striven for integration through provision of high quality service. For more than a year now the provincial Vegetable Research Institute has taken up 32 joint projects with 27 units, they have disseminated 8 achievements, have developed 10 technologies, and they have created more than 1 million yuan in economic results for society, and the research institute itself has increased its income.

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NATIONAL DEVELOPMENTS

RENOVATION OF EXISTING ENTERPRISES URGED

Tianjin JISHU SHICHANG BAO in Chinese 3 Dec 85 p 1

[Text] What reporters have learned from the 3d National Working Conference for Enterprise Technology Advancements: During the "Sixth 5-year Plan," China quickened the pace of carrying out the technical restructuring of existing enterprises. The growth rate in investment for technology transformation has already exceeded the growth rate for capital construction investment, and the tendency toward new construction of enterprises, outward expansion, and a neglect of technical transformation that has characterized production construction for some time has begun to turn around. From the central authorities down to the local areas, a great deal of work has been done in the technical transformation of existing enterprises, especially in the areas of improving product quality and technical standards, increasing the types of products, saving energy, and improving capacities for export and the earning of foreign currency. Products in short supply have been increased, which has allowed for a readjustment of structures.

From 1981 through 1985, total national investment in technology transformation has been more than about 140 billion yuan, of which more than 100 billion has been allocated by the state. This has focused on arranging energy conservation and coal-for-oil substitution projects and has concentrated on measures to increase production of products for the light industry and textile markets, for machinery and electrical products in short supply, for entire complements of raw materials, for enhancing transportation and shipping, and for mining safety. During this period the state has also begun to grant 35 billion yuan in special loans for light industry and textiles, energy conservation, machines and electricity, vehicle and ship purchase, and raw materials. To increase the pace of technical transformation, there were additional grants in 1984 of discounted loans. Beginning in 1983, the state allocated special foreign exchange to import advanced technology to transform existing enterprises, and also formulated plans to import 3,000 items in 3 years. At the same time, it began running experimental sites in Shanghai and Tianjin with expanded authority to import technology, and along with this, it also expanded to other coastal cities and to cities with experimental sites in system restructuring. It quickly put new perspectives on the importing of technology to transform existing enterprises.

Based on materials supplied for relevant areas, during the "Sixth 5-year Plan" it is estimated that 200,000 projects were built and put into production, of which more than 500 were worth more than 10 million yuan, with gains in fixed assets of 110 billion yuan, which is about one-fifth of the original value of fixed assets for state-run enterprises throughout the nation by the end of 1980.

During the "Sixth 5-year Plan," China also hastened programs to use foreign capital to transform enterprises. Through Chinese-foreign joint ventures, Chinese-foreign cooperative ventures, compensation trade, and other projects, China has brought in technology and management methods, and imported equipment, which have had positive effects on the improvement of product quality and economic results, and have given impetus to equipment renovation.

During the "Sixth 5-year Plan," as restructuring of the economic system developed and as existing enterprises played their full roles, and as the potential of older enterprises has been tapped, there have already been clear results in economic construction. Of increases in industrial gross output value for this period, two-thirds depended upon technical advances in existing enterprises and upon enterprise reorganization. Dependence upon advances in enterprise technology will have a major effect on invigorating the national economy.

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NATIONAL DEFENSE INDUSTRIES STRESS CIVILIAN PRODUCTS

Beijing GUANGMING RIBAO in Chinese 24 Dec 85 p 2

[Article by Peng Ziqiang [1756 1311 1730]: "National Defense S&T Industries Enhancement of Civilian Production Invigorates Urban Markets"]

[Text] During the sixth 5-Year Plan, national defense science and technology industries diligently implemented the principle of "military and civilian integration," actively organizing the production of civilian goods in short supply. This served the national economic construction and the material life of the masses and strongly supported urban markets.

As for example in the area of coal industry machinery, military industry enterprises have gone into the production of entire sets of equipment for excavation, for safety and self protection, for loading and unloading, and for shipping. They have accumulated 28 sets of large scale mining hydraulic supports that must be imported for production, as well as 250,000 sets of mining protection devices; machinery for loading, tunneling, bulldozing, and vehicular transportation are currently under trial production. In the areas of transportation and shipping, the military industry enterprises have created vehicle models other than medium size because of the situation in the Chinese manufacturing of vehicles where "there is a lack of the heavy and few of the light." These include heavy-duty, light weight, miniature, and vehicles for mining use, as well as various special use vehicles, all of which are in production. The Ministry of Aeronautics Industries has also produced types of shipping machines, specialized machines, and helicopters, and five types of extra-light and light aircraft. They have begun to provide these for civilian use and for the use of relevant departments.

Various departments in the national defense science and technology industries are vigorously producing light industry commodities to satisfy the demands of urban people to improve their material lives. Over the past few years they have accumulated or produced 1.5 million motor vehicles, which is more than 70 percent of national production. And they have manufactured more than 40 kinds of medical and hygiene equipment, and are as well just in the process of manufacturing a batch of new model medical instruments, as for example a dislocation scanner, a very high speed centrifuge, and a laser cancer treatment machine.

Military industry enterprises have already provided more than 60 kinds of spare parts for primary maintenance of complete sets of imported chemical fiber and steel rolling equipment, which has saved a great deal of foreign exchange. As for example a hydraulic reservoir spare component for the 1.7 meter steel rolling machine provided by Factory No 527 of the Ministry of Aeronautics Industries, which in its 3 year use has saved more than $1 million. The electro-hydraulic servo valve used in this steel rolling machine was successfully produced by a certain research institute of the Ministry of Aeronautics Industries, the performance and quality of which was completely at the level of similar international products.

As the military industries are producing civilian products "in short supply," they are supporting a large group of small to medium enterprises through various means like transfer of the rights to the achievements of scientific research, sale of scientific research products, and transfer of know-how, which has helped them to take off economically.

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NATIONAL DEVELOPMENTS

EMERGENCE OF CIVILIAN S&T DEVELOPMENT ENTERPRISES DESCRIBED

Beijing RENMIN RIBAO in Chinese 1 Feb 86 p 3

[Article by Xiao Guan`gen [5135 7070 2704]: "A Number of Civilian Science and Technology Development Model Enterprises Are Springing Up"]

[Text] Fifty civilian science and technology development model enterprises supported by the Shanghai Science and Technology Development and Exchange Center have already become an important force in the enlivening of technology markets. Last year they signed more than 1,000 contracts of various types with production units, for a total amount of 100 million yuan. Among them, 134 projects involved 33 enterprises developing technical achievements that were "short, even, and quick," 10 involved applications for patents, and there are 89 factories jointly operated by small to medium-sized enterprises in this city and outside areas and by town and township enterprises.

Funding and preparations were made for the construction of these science and technology development model enterprises by a number of scientists and technicians from the former units who were not institute directors, as well as by scientists and technicians in retirement or early retirement. These enterprises chiefly engage in technology development, technical service, technical consulting, technical training, and packaged engineering contracts. Based on market requirements, they select and establish projects for development, many of which are projects that national research units are unwilling to take up or cannot be bothered with, and they are done with little investment, fast turnover, and with quick results. After the "infrared contactless power igniter," successfully developed in 4 months time by the Creative Electronic Engineering Company, was used on vehicle engines, fuel consumption was reduced by from 7 to 10 percent. The "universal vision corrector" of the Institute of Modern Information Technology has had good results when treating myopia, cross-eye, and wall-eye in youth. Within a month after going on the market, there were more than 5,000 telegrams requesting rights to transfer of technology and for resale of the product.

As civilian science and technology development model enterprises are developing technical services, they are particular about speed and quality in order to gain a good reputation. Because dust removal equipment at the Shanghai Dongfeng Needle Plant was deficient and it had no sound insulation, both sound and dust pollution were serious problems, to which surrounding residents objected strenuously. The plant decided to commission the Engineering Technical Equipment Outfitting Company to resolve the pollution problem. The company immediately sent people to the site for a thorough inspection and proposed a control program. Within this rather short time, they solved both the dust and noise problems.

These civilian enterprises are all in their initial stages. To help them maintain proper directions and to develop healthily, the Shanghai Science and Technology Development and Exchange Center has established special structures to strengthen management, has formulated some rules, and has corrected in time some mistaken ways of doing things. Beginning in October of last year, they carried out an audit of financial affairs and a full-scale reorganization in concert with city business and tax revenue departments.

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NATIONAL DEVELOPMENTS

ROLE OF S&T CONSULTING WORK DISCUSSED

Beijing KEYAN GUANLI /SCIENCE RESEARCH MANAGEMENT/ in Chinese No 4, Oct 85 pp 7-9

/Article by Zhao Yingchun /6392 5391 4783/, Heilongjiang Province Science and Technology Association: "Scientific and Technological Consulting in the New Situation"/

/Text/ Scientific and technological consultation in Heilongjiang began to develop extensively after conscientiously implementing the directive of Zhao Ziyang, President of the State Council Zhao Ziyang's directive of 31 August 1980: "Scientific and technological consulting service work is very important, it is a form for scientific and technological sections to move towards socialization and experience should be summarized constantly." There are science societies engaged in it, there are grassroots level science and technology associations engaged in it, there are science and technology associations systems engaged in it and they are interlocked in all directions to form a huge organizational network.

I. Scientific and Technological Consulting is a New Thing on the Leading Edge of Reform

The time when scientific and technological consultation service was just taking its first steps was during reform of the national economic system, implementation of scientific and technological systems, and when a series of problems in understanding had not yet been resolved, and capitalizing fully on the advantages of the special cross-linkages, scientific range, density of knowledge, abundance of talent and the detached and unrestricted and unbiased nature of scientific and technological mass organizations broke through the limitations of unit, section, and regional ownership systems to promote the rapid transformation of science and technology into a productive force, realize the commercialization of technological results, and push forward the probing, test range, and developmental undertaking which emerged from subsequent reform of the scientific and technological system. It was an undertaking that got quick results with little investment, had the support of the people and was in line with the will of the people, and had significance for the public good of society, it was an essential constituent part of the comprehensive reform of party and country, and it was a new thing for socialist modernization. Therefore, scientific and technological consultation service developed very fast and increasingly displayed a powerful vitality.

In 1984, scientific and technological consultation service organizations at all levels within the provincial scientific and technological association system did a great deal of work for leadership policymaking consultation, for large project appraisal, for medium- and small-scale enterprise technological service, and for providing information to scientific and technological and specialist users. Over 2,100 scientific and technological consulting projects were carried out during the year in communications, energy sources, environmental protection, agriculture, water conservancy, and medicine and public health with direct economic benefits to the nation of over 380 million yuan. Among them, hard vinyl floor tiles, hard surface cold forging, Baidun /4102 0903/ deoiled milk powder, Haolanghe self-supplying power station, Heping Highway overhead crossing bridge and defective welds in Gexi heating plates all of whose economic and social benefits are very clear and earned the high regard and welcome of party agencies and enterprise units at all levels. Up to the end of last year, the number of scientific and technological consultation service organizations at all levels in the provincial scientific and technological association system had increased to 438 with a staff of over 2,000 specialists.

Scientific and technological consulting has also encountered some problems under the new situation. Beginning in mid-1984, "companies" and "centers" of all types appeared in society in rapid succession. Some operated under the banner of "reform," utilizing the name of "company" and "center" for swindling, buying and selling for a profit, and for trafficking in state-controlled goods and materials interferring in the smooth progress of system reform. Their phony consulting has created many bad influences. In some areas such as management content, range of activity, distribution of rewards, and professional administration to varying degrees there are some problems where the purposes and demands of the consultation do not coincide. These should all be corrected. The /1984/ Central Document 27 (below, Central Committee Doucment 27) issued by the Central Committee of the CPC was correct and timely. Through thorough implementation of this memo, while correcting new incorrect style, true and false can be distinguished, the correct can be upheld and the incorrect driven out, to wipe out thoroughly such corrupt things as policy violations, interference with reform, and feathering nests at public expense. At the same time, it is an examination and a test of our scientific and technological association system's consulting. If the pace is correct, then it will continue to develop; if mistakes have been committed, they should be resolutely corrected; everything that goes against the Central Committee Document 27 can be thoroughly banned. To ensure the healthy development of scientific and technological association system consultation work, consulting departments at all levels in this system should resolutely and conscientiously implement the Central Committee Document 27 and should report the implementation situation and the problems encountered to successively higher levels to facilitate summarizing experience and continue to advance.

II. We Should Have a Clear Understanding of Scientific and Technological Consulting Work Under the New Situation

A scientific and technological consulting company or center is an "intellectual property" which adopts a definite economic means, promotes the integration of science and technology and economic construction and emphasizes service. Its administrative content and business scope do not permit illicit purchase of goods and materials which are in short supply nationally, even less does it permit speculative buying and selling; nor is its aim the direct production of commodities for sale in the market. As concerns the integration of technology and trade, the integration of technology and the economy and the commercialization of technological results in consulting work, although "trade," "economy," and "commerce" are all involved, they are still linked to technology and thus cannot change its basic attributes. For this reason, scientific and technological consulting service companies and centers are neither commercial businesses nor enterprises, but are a third type of property which is engaged in the transfer of intelligence, and from the very first day of its birth, sanctioning departments have clearly stipulated that they are units under the leadership of scientific and technological associations or societies. The primary focus of Central Committee Document 27 was use of the authority in hand in the name of "reform" without regard for the interests of the party and nation to pursue the private ends of the unit, small collective and individual and blinded by lust for gain unscrupulously harmed the nation, hoodwinked the masses and sought private gain at public expense. But our consulting service departments were set up several years ago already in accord with the spirit of Premier Zhao Ziyang's directive and the regulatory system it now has in effect was implemented after approval by the main leadership departments of the nation and it is different from the commercial and enterprise "companies" and "centers" which were all the rage in society. It conforms to the spirit of scientific and technological system reform and its direction is on the right track. It is necessary to enrich it continuously, improve it constantly, strive to strengthen it, and develop it actively. For this reason, it is necessary to clarify the following several problems in understanding.

1. We should distinguish between correcting incorrect styles and problems which appear in the progress of scientific and technological consulting. Even now, scientific and technological consulting is considered a newborn baby and there are many places which have not been adequately improved. However, its existence and development are beneficial to the prosperous development of the nation, are beneficial to the prosperity and wellbeing of the people, and are beneficial to the building of a socialism which has a Chinese character. This is fundamentally different from the erroneous method of viewing only the private gain of the department, small collective, minority or individual and in the process forget its significance.

2. We should distinguish between normal income from engaging in consulting work or concurrent employment in accordance with the stipulations and illegal gains. Carrying out one's own job without encroaching on the national or collective economy and technological rights and interests and engaging in consulting or concurrent employment with the approval of the unit conforms to the demands of the Central Committee's decision to reform the scientific and technological system and should be compensated according to the regulations. Receiving a little more due to making a practical contribution or even being granted a large bonus for a major contribution is perfectly reasonable. This cannot be mentioned in the same breath with such erroneous behavior of illicit purchase of goods and materials which are in short supply nationally, speculative buying and selling, and engaging in illegal income.

3. We should distinguish between making good on a contract after the project is completed and taking advantage of reform to award bonuses indiscriminately. Completion of a contract project converts science and technology into practical productive forces obtaining economic benefits and making a contribution to the four modernizations. Awarding compensation in accordance with contract stipulations is natural. This is different in essence from such behavior which goes against financial and economic regulations as inventing names, scheming to pick up some ready cash, and distributing money and goods under false pretenses.

4. We should distinguish between engaging in pilot project with the approval of upper echelons and in line with the demands of upper echelons and exploring the laws of consulting work on the one hand and damaging party policies in force and interferring with state plans for consumer capital. Pilot projects are carried out in a few or individual consulting departments or units with the aim of gaining experience and do a good job of reform work by using experience in single areas to promote work in the entire area and even if there are errors or complete failures, it will not and cannot influence the overall situation. Thus, it is natural that some pilot projects may conflict with policies in force but it cannot have an impact on the overall plan for consumer capital.

If we do not clarify the above problems and uniformly regard developing advancing consulting work as a new incorrect style but strangle it in the cradle, that will be going against the spirit of the Central Committee's reform. At this critical time, scientific and technological associations should take advantage of the party's "bridging," "linking" and "helping" roles to safeguard thoroughly the initiative of scientific and technological workers to search freely for topics in production practice.

III. Correctly Handling Problems in Going Forward, Developing a Generally Good Situation

Scientific and technological consultation service is a new undertaking and in carrying out the stipulations of the original document it is necessary to discover problems and research problems and summarize things which have some regularity and supplement and improve them. However, before the upper echelons stopped using it or had not yet put out new stipulations, the stipulations of the original document were still valid. When contradictions with the actual situation or certain policies were encountered they could be reported to successively higher levels. If there were some clear stipulations in the Central Committee document, then the Central Committee document should be taken as correct. The professional scope, the system of distributing allowances and bonuses, and tax breaks have not changed. Consulting departments run by societies are a subsystem of the scientific and technological association consulting organization and they are a unified entity and the parent company or center which already has a license need no longer make this demand on consulting departments run by societies to comply. Besides, in the light of the nature of the scientific and technological service company or center, whether or not to do business this way is a question that still requires further study.

Concerning the question of agency working personnel engaging in consultation service work, Sec 1 of Art 7 of the Document 83 /1983/ issued by the Heilongjiang Government Administration stipulates: "On the condition that their own work tasks have been completed and with the agreement of their unit, scientific and technological personnel may accept temporary employment from outside units. The monthly income is not to exceed the individual's monthly wages, the individual's unit be exempt from proportion deduction." In the spirit of Secretary Li Li'an's /2621 0500 1344/ talk at the Provincial Scientific and Technological Work Conference, substantial rewards for scientific and technological personnel cannot be viewed as an incorrect style under the new situation. Thus, for agency scientific and technological personnel to participate in consulting work in line with stipulations and to receive compensation is fair and reasonable and they cannot be censured for it. Although consulting companies or centers are by nature not commercial businesses or enterprises, until the Chinese Scientific and Technological Association issues a new opinion, agency leaders without exception should not hold two posts concurrently (those who are holding two posts concurrently should stop).

Scientific and technological consulting service work developed in the past under rather difficult conditions and now the pace has increased and the way also has fundamentally cleared up. The Central Committee of the CPC's "Stipulations on Reform of the Scientific and Technological System" said that we should actively develop trade activity in technological consulting and technological service and this confirms even more that our development direction is correct. However, problems will always be encountered in moving ahead and we should permit errors in reform but we cannot permit no reform. We should take a positive attitude and use the party's policy, especially the spirit of reform of the scientific and technological system, to supplement, perfect, and support scientific and technological consulting service work, help them overcome difficulties, resolve problems and continue to move forward on the new journey.

There are now some problems in scientific and technological consulting work that need to be explored and resolved: One, the question of name. We are mass organizations that engage in consulting service and since in essence there are differences with "companies" and "centers," in name too our characteristics and properties must be appropriately reflected. Two, the problem of a board of directors. Consulting service board of directors is its highest organ of power, its existence produces a contradiction between the parent company or center and the leadership of the scientific and technological association committee, contradictions between the branch companies or centers and the leadership of the society's board of directors, yet abroad, the board of directors is also an organizational structure of a commercial nature. At present we should consider the need for the existence of this organizational level. Three, the question of licenses. Since consulting service is an intelligence conversion (intermediary) type unit whose aim is service, whether or not it definitely should have industrial and commercial licenses, since nationally there are many places which perform consulting service work but have not received licenses, this requires further appraisal from a legal standpoint. Four, the question of service channels under the new situation. Many of our original advantages were manifested under conditions in which such problems as economically the lack of a relaxed, scientific and technological system operating mechanism. The reform of the situation challenged us and it is necessary to seek a new path for consulting service work. In addition, there are such problems as the form and tax revenues of industrial and mining consulting service and the professional scope of design unit consulting service organs. On the basis of practice, these problems must be conscientiously analyzed and researched, bases must be found, directions must be clarified, and at the appropriate time they must be solved.

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NATIONAL DEVELOPMENTS

HIGHER INSTITUTIONS IN S&T MARKETS DISCUSSED

Tianjin KEXUEXUE YU KEXUI JISHU GUANLI [SCIENTIOLOGY AND MANAGEMENT OF S&T] in Chinese No 11, 15 Nov 85 pp 32-36

[Article by Tao Weijiang [7118 5898 3068]: "Some Reflections on the Function of Higher Level Institutions in the Technology Markets"]

[Text] Socialist technology markets have been formed through the state, groups and individuals, and the integration of autonomy in technology trade and the support of administrative departments. Their appearance breaks up the former science and technology [S&T] situation whereby science research, production, and the economy were divorced from each other, and they create the conditions in which to resolve the abuse of having "two skins" over science and technology and economic construction. Also they have accelerated the movement of talent and the circulation of technology. Technology that circulates in the form of commodities will also propel forward the restructuring of the science and technology system, as well as the dissemination, improvement, and transfer of science and technology. Therefore, the future of technology markets is expansive, and of great hope.

China's higher institutions have assumed the dual functions of training high level specialist technical personnel and of developing science and technology. There are at present more than 390,000 teachers and science research personnel, among which are one-half of this country's high level intellectuals. They are training 80 percent of the nation's graduate students, including both the social and natural sciences. The curriculum is complete and there is quick access to scientific and technical information, and there is as well the capability to organize more classes, to solve comprehensive major problems in science and technology, not to mention the ability to open up new products, new technology, and new techniques for small to medium enterprises. Up until now, higher institutions have been awarded 56 prizes in the natural sciences, which is 45.2 percent of those awarded in the natural sciences, and have been awarded 221 prizes for inventions, which is 24.4 percent of those given throughout the country.

However, on the other hand there are still problems when one compares the abundant real technical capability with the effect on the technology market of enterprises, companies, and research academies (institutes) and also its direct role on social and economic development. The author feels that applied science research in higher institutions should pay close attention to the following points.

I. Take the initiative in developing projects that are "short-term, within ones means, and show quick results."

Currently, township and town, and privately funded enterprises are developing quickly, but they remain technically weak and deficient in capital. They can only hope for large projects and large products but cannot attain them, even if larger enterprises have no particular interest in them. Especially for longer term projects and products, in fear that funds might lay idle too long, medium to large enterprises cannot keep up with changes in the market. Therefore, there is often the situation where medium to large enterprises are not very enthusiastic about the application and dissemination of scientific and technical achievements, but neither can small enterprises accept them (due to funding and technology factors); when the rights to technology are transferred, they dare not put up the capital, and even with the amount shared several ways they fear they will lose out, so it is difficult to make deals. But those small projects and small products where investment is small, development time short, results are quick, and there is a market for them, they just fit the demand and are taken up in a moment. The situation for higher institutions is often like this: some teachers are good at the theoretical research of basic science, and publish several papers each year; whereas, other teachers are better at taking on applied topics, and therefore, the science and technology management departments of higher institutions should emphasize both basic and theoretical research and research into applied topics. Based on market demands and market adjustments, they should organize those teachers who are good at dissemination of applications to take the initiative in developing short term, balanced, and quick projects. They can even adopt various formats of responsibility systems to attract teachers into taking up applied research, and directly serving social and economic development.

II. Earnestly aim at applications, be conscientious about substantial results.

Higher institutions ought to have intellectual reserves, and ought to have about 60 percent of their capacity engaged in the theoretical research of basic science, and based on the specialties of the school, can establish classes that focus on research, and within several years or a decade there will be breakthroughs to enter the ranks of international or domestic advanced levels. At the same time as this, about 40 percent of capacity should be put into actively taking the initiative to develop research into application topics, and to provide even more new products, new technologies, and new techniques for opening up the technology markets. This is also for accepting topics through various means that industrial departments encounter in actual production, that is, topics outside of planning. And, to constantly lead reserve knowledge or technology through horizontal relations to production departments, to feed technical difficulties from small to medium enterprises back to the schools, and to organize strength into making short term breakthroughs, allowing the potential of both parties to be fulfilled. When transferring the rights to technology, they should work toward perfecting one, then transferring one, and should evaluate the maturity of any technology from the point of view of society, the market, and applications. Trade may be done through an intermediary, which causes the market to be even more dynamic.

III. Directions should be flexible, policies should be implemented.

It is recommended that we draw on the experience of privately run technology institutes and science and technology development companies regarding the flexible and expedient, yet sound methods to develop technology markets. They are not limited to a certain field or a certain discipline, but do whatever the market needs. They do not need a state allocation system, nor do they need state allocated expenses, for on the one hand they take on research topics that are needed by the market, and on the other, organize their scientific and technical capacities. When things have been sized up, they act, when projects are completed, they let them go. Scientists and technicians get paid according to their efforts, and profits are distributed according to the degree of technical advancement and the degree of difficulty, as well as the degree of contribution toward completion of the project. This kind of management method is similar to the way some higher institutions plan application research topics based on disciplines, but is also different. Where it is similar is that things are tailored to capabilities; where it is different is where one person can measure the cloth to fit the body, but another does not do it that way. As the technology market develops, application development must be social, comprehensive, and flexible, and must accelerate cross fertilization and permeation of disciplines, as many projects will transcend departments and disciplines, and even the scientists and technicians that are involved in a project will be from different units and different categories. For these reasons, the technology markets have posed new demands for science and technology management in the higher institutions. Science and technology management includes the determination of research directions and planning, and the implementation of corresponding policies and measures. For a long time now, technology has been rather backward in many production fields, and the capability for large scale production of inexpensive, high quality products has been low. When the reasons for this are discovered, it is found that it is because intellectual labor and its material value have not been acknowledged, and even less has it been taken onto the track of commercialization. The appearance of technology markets and the commercialization of technical achievements have brought convenience to the implementation of science and technology policies.

As awareness of science and technology markets deepens, as long as directions are flexible and policies are implemented, the function of higher institutions in the technology markets will go up another story.

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HUBEI ACTING GOVERNOR ADDRESSES SCIENTIFIC EDUCATION MEETING

HK061137 Wuhan Hubei Provincial Service in Mandarin 1100 GMT 2 Mar 86

[Text] The provincial government held a meeting on the work of the scientific education front of the whole province in Wuchang from 22 to 26 February, stressing that governments at all levels should include all aspects of work of the scientific education front in the focal points of government work, strengthen leadership, and grasp it firmly and well.

In his summing-up speech, Guo Zhenqian, deputy secretary of the provincial CPC committee and acting governor, said: At present, the level of agricultural production in our province is not high, the quality of industrial products is poor, and benefits are not ideal. One of the very important problems is that our scientific and technological development and training of qualified personnel cannot catch up with the situation. Governments at all levels must further heighten understanding and really strengthen leadership over scientific and technological work.

He said: We must adhere to the orientation of gearing scientific and technological work to the needs of economic construction and of serving economic construction. Over the past few years, our province has scored some 1,000 items of important scientific and technological achievements but the majority of them have not been applied to production. This is a very big waste. If we seriously grasp well the popularization and application of the existing scientific and technological achievements and transform science and technology into productive forces as soon as possible, this will have very great potential. We must gradually establish a network of technological markets at many levels, through many channels, and in many forms to promote the transfer of scientific and technological achievements.

Guo Zhenqian pointed out: Governments at all levels must attach great importance to the development of intellectual resources, regard training qualified personnel as an important matter, and grasp it well. While guaranteeing the quality of the 9-year compulsory education system, we must develop vocational and technical education. Capital construction for the development of intellectual resources is the building of the ranks of teachers. These ranks must be expanded and their quality improved. In the future, except for the selection of leading cadres at and above the county level, no units are allowed to transfer teachers from middle and primary schools. Those who have been transferred must be returned as soon as possible to the profession they were trained for.

In conclusion, Guo Zhenqian emphasized: The scientific education front and the work of all departments are important contents of building socialist spiritual civilization. Those who engage in building spiritual civilization must first grasp well the building of their own spiritual civilization, adhere to the four basic principles, and avoid and overcome all unhealthy trends.

Vice Governor Liang Shufen spoke at the beginning of the meeting.

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NATIONAL DEVELOPMENTS

REFORMS IN DEFENSE INDUSTRY RESEARCH INSTITUTES

Beijing KEYAN GUANLI /SCIENCE RESEARCH MANAGEMENT/ in Chinese No 4, Oct 85
pp 25-27, 30

/Article by Liu Fohua /0491 0154 5478/, 29th Institute of the Ministry of Electronics Industry: "On Reforms in Defense Industry Research Institute's Organization-Management Structures"]

/Text/ "The Resolution of the Central Committee of the Chinese Communist Party on Reform of the Scientific and Technological System" pointed the direction for reform of the national defense scientific research system. Reforming the national defense scientific research system currently in force must accompany reform of the defense industry research institute organization management agencies, and this paper attempts to discuss several views on this question.

I. Establishment of Organization-Management Structures Should Be Favorable to Thorough Implementation of the Principle of "Guaranteeing Completion of National Defense Tasks and Shift Military Research Results to Civilian Use, and Establish a New Integrated Military-civilian System of Organization."

Although China's national defense scientific research system now in operation has gone through some adjustment, basically it was inherited as a package from the Soviet Union, there is a chasm between military and civilian scientific research under unalterable security regulations, policies and stipulations, the results of military scientific research cannot be rapidly and effectively converted to civilian use which to different degrees influences national economic construction and is not suited to the demands of the four modernizations. The "Resolution" clearly states: national defense scientific research organizations should set up a new system of military and civilian integration, and while guaranteeing the completion of national defense tasks, it should be geared to economic construction, accelerate converting the results of military technology to civilian use, and vigorously launch developmental research on commodities for civilian use. To set up this new system, when reforming the defense industry research institute organization management structure, separate military and civilian product technology management organizations (such as military products technology office and civilian products development office) should be set up under the responsible leadership of the director helped by the chief engineer. They are responsible respectively for military and civilian product technology management, including formulation of long- and short-range technological development plans; determining the basic scientific research and applications research projects to be launched; are responsible for organizing appraisal of proposals for organizing research and trial manufacture projects and appraisal of technological key projects and scientific and technological results; are responsible for organizing solutions to technological problems which crop up in production projects, are responsible for authorized management of military and civilian product technological reports, technological market survey research and analysis to provide decision making materials to leadership in a timely fashion. The civilian products development office also should be responsible for converting the results of military technology to civilian use and for technological consultation service work abroad. To strengthen plan administration management, we should set up a plan administration office under the responsible leadership of the director helped by the deputy director of plan administration who is responsible to the director. The planning administration office is responsible for authorized administration of military and civilian product research, trial manufacture and production planning, is responsible for authorized administration of technological administrative planning, commodity sales, and economic benefits planning, is responsible for compensated contracts and various administrative contracts, and signing of sales contracts, is responsible for coordination, balance and implementation of project plans. Research institutes with the necessary conditions may also start up, as appropriate, military and civilian products research laboratories and trial manufacture production shops so as to be able to concentrate their energies on the work at hand and resolving contradictions encountered in the process of military and civilian product plan implementation.

Plan administration management and military and civilian product technology management are two very important aspects of scientific research management work and under the unified leadership of the director dividing the managerial labor among the three above-mentioned departments each with its own tasks and responsibilities is favorable for opening channels of communication for plan administration and technological direction management, is favorable for being more thorough and improving management work, and is favorable for improving work efficiency.

II. Establishing of Organization-Management Structures Should be Favorable to "Changing Track and Changing Form," Developing From Pure Scientific Research to Scientific Research Administration

Although there have been many advances and improvements in financial management in defense industry research institutes in recent years, such as implementing control of administrative management expenses, and some have also carried out cost accounting work. However, because in the past what was implemented was a system for supply of scientific research enterprise administrative expenses and did not concentrate on control and management of scientific trial-manufacture costs and management expenses, there were neither working organizations nor a set of measures and methods, not to mention a lack of managerial talent in this area. Up to the present, the overwhelming of financial departments settle accounts according to the amount of the ultimate expenditures. Thus, in the process of research and trial-manufacture, without computing costs, such phenomena as extravagance are rather serious, and the idea of economy is lacking among engineering and technological personnel. If this situation is not overcome, it will be very difficult to adapt to the demands of reform of the scientific and technological system, because the "Resolution" stated: for important scientific and technological research which is part of central and local planning, planning management also should utilize economic levers, observe the law of value, and gradually carry out on a trial basis management methods oriented towards open bidding and signing of responsibility contracts. It is very clear that a research institute whose management level is low, consumption is large, and cost expenditures are high is one which cannot win in open bidding. If by chance one wins the bid, one is also forced to adopt measures to lower expenditures and reduce costs. In view of the above factors, it is very necessary that an accountant be assigned to the research institute to implement an accounting system. He helps the director stress cost control of scientific research trial manufacture. At the same time, a specialized agency should be created in the finance department and an economic accounting network suited to the research institute should be established to take care of routine work. It should stress effectiveness with such relevant departments as plan administrative management, technological management, quality control and goods and materials management to facilitate the rapid conversion from pure scientific research to scientific research management (or scientific research production).

III. Organizational and Management Structures Should Be Simple, Unified, Efficient

For this, it is necessary to do the following:

First, similar organizations should be unified, similar tasks should be classified, similar procedures should be combined, organizations which should be shut down, resolutely shut down, those which may or may not be established should uniformly not be established. We should work hard to simplify organizations and keep the personnel small in number. For example, after implementing the director responsibility system, middle level cadres below assistant director in scientific and technological and administrative areas are appointed or engaged by the director and after the management of these cadres has been separated from the party committee office, they can be combined with the worker personnel department under unified management and no cadre office need be created. To stress in a unified way the training and employment of personnel, technological education also should be combined with the worker department and called worker and education office.

Second, there should be systematic and clear decisionmaking and management levels and responsibility. The decisionmaking level is headed by the director, with the participation of the deputy director, chief engineer and chief accountant, and when necessary leaders from relevant departments can be called on to participate in meetings to ensure timely decisionmaking and not miss a timely opportunity. The management level is made up of the leaders of the function management organizations to ensure the execution of the leadership decisionmaking.

Third, organizations must be in matrix form. With the help of the deputy director, chief engineer and chief accountant, the director carries out vertical leadership of the function management departments, with each attending to its own duties, bearing its own responsibilities strengthening horizontal coordination, to guard against intersecting leadership and command, otherwise there will be chaos.

Fourth, improve the quality of management personnel and the combination of vocational work and intellectual ability of management personnel should be rational. The closed style of defense industry research institutes of the past is now oriented towards society and towards economic construction, launching technological administration and development of civilian commodities is bound to encounter many new situations and problems in management work, and this requires a group of able and efficient management personnel. Thus, improving the quality of management personnel, reducing administrative personnel, and coorespondingly increasing the special management personnel (such as technological administration and distribution personnel, management personnel of reliable quality, accountants, economists) reforming the combination of vocational work and intellectual ability of management personnel is an important task facing research institutes. To resolve this aspect of management personnel, one, ask the nation for allocations; two, carry out our own program of selecting candidates to be send for advanced training; three, train candidates in actual work and encourage them to pursue self-study.

Fifth, we should improve the position and treatment of management personnel, especially those who do well in management work. We should reward people according to merit and give important rewards for important contributions so that they will keep their minds on management work. The key here is that we should improve the understanding of the leadership about the importance of management.

On the basis of the above demands, we propose a reference scheme for establishing local (divisional) level 1,000-2,000 man defense industry research institute organizations, see table for details.

IV. Establishment of Organization Organizations Should Be Beneficial to Strengthening Democratic Management

The broad engineering technological personnel and workers are the main body of the research institute employees, they are the masters of the research institute, while the director is a leader and public servant. After implementation of the director responsibility system, whether or not he can maintain and strengthen democratic management involved the direction of research institute reform and is related to the problem of whether or not he can implement the "Resolution." Employee representative assemblies in enterprises are an important form for strengthening democratic enterprise management. This writer believes that although the research institute has a mass-type academic organization--the technological committee--which is an organizational form for developing technological democracy, it cannot take the place of the role of the worker union and employee representative assembly, thus this worker union should be established and the employee representative assembly system implemented. The research institute is a place where intellectuals are concentrated, and in the past under "leftist" thinking, workers and intellectuals were thought to be worlds apart: the former had been educated, the latter had received re-education. But now the intellectuals are part of the worker class and it is absolutely necessary for research institutes to create worker unions and carry out a system of employee representative assemblies. Its necessity and importance are outlined below:

First, legislation. According to relevant stipulations from the state and upper echelons, through broad discussion, approval and formulation of the research institute laws and regulations and relevant rules (also called the fundamental law of the research institute) by employee representative assemblies, it is published and carried out by order of the director so that the research institute gradually moves towards a legal system. With the passage of time and changes in the situation, when it is necessary to revise and supplement it, it is again discussed by the employee representative assembly and this task is carried out. In this fashion, the democratic rights of the employees can be enforced, they can be masters of their own house, increase their sense of responsibility as masters, and give full play to the wisdom of the masses and it also can ensure the continuity of the research institute laws and regulations which is beneficial for thorough execution.

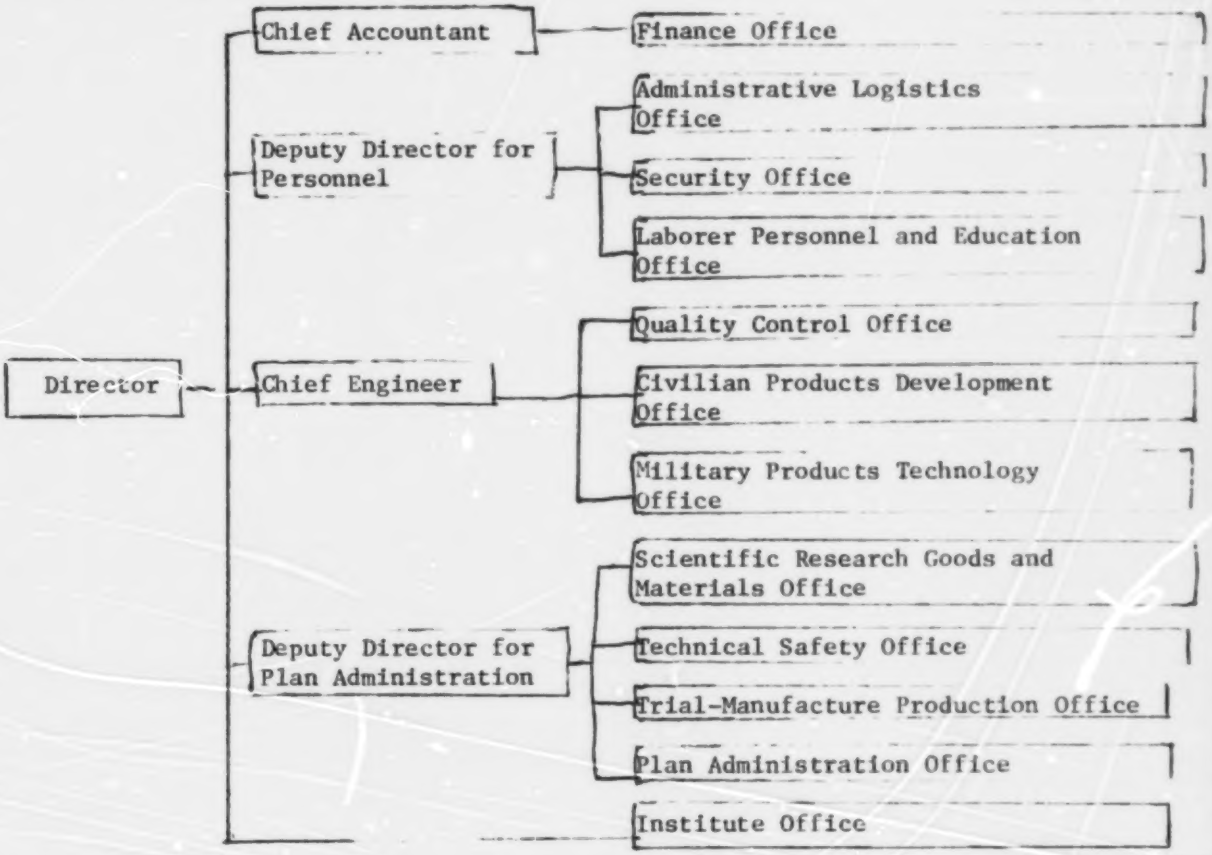
Second, organization mobilizes the employee masses to carry out the tasks. At fixed intervals the director gives a work report to the employees representative assembly, puts forth tasks and demands, mobilizes and appeals to the entire body of employees to make suggestions, and strives to realize the struggle goals of the institute. Some major problems can also be turned over to the employee representative assembly for discussion and investigation to reduce or avoid errors in major problems. For example, in the major question currently of the overall proposal for reform of the research institute system, if the reform draft is turned over to the representative assembly for discussion, it can both pool the wisdom of the masses and add to the improvement of the revision as well as lay a ideological foundation and mass foundation for reform which will be beneficial for promoting reform.

Third, democratic evaluation of leadership cadres at various levels at set intervals. The worker union or employee representative assembly should have the right to propose commendation and rewards for cadres and have the right to propose recall of cadres who are unqualified or commit serious errors, and to receive and approval petitions in accord with the jurisdiction to appoint and remove cadres. The above actions will place cadres at all levels under the supervision of the employee masses, which is favorable for correcting incorrect work styles and ensures the thorough implementation of the party's line, principles and policies.

Fourth, democratic election of the director. The research institute implements the director responsibility system and the director is appointed or engaged by the upper echelons. The following procedures may be adopted for the appointment of the director. Before appointment or engagement, upper echelon organs send someone to the institute to attend the employee representative assembly. At the assembly, candidates for director give a campaign speech (including the struggle goals they would like to achieve after their election within a certain period and the measures and methods to be used to achieve these goals), then the representatives participate in a secret ballot and the person receiving the greatest number of votes is elected and immediately a military order is issued requesting upper echelons to investigate the appointment, then the director appointed forms his cabinet. This is also a good method which should be used on a trial basis in the reform of the cadre system. It is beneficial for discovering talented persons and promoting worthy and capable people.

Fifth, safeguarding the lawful rights and interests of the employees is not violated. Worker unions are the research institute's employee mass organizations, the employees' family. If the lawful rights and interests of the employees are violated, the worker union can be asked for help in resolving it, and the worker union has the responsibility to come out boldly; safeguarding the lawful rights and interests of the employee masses is done through normal lawful means.

Sixth, helping the director deal with relevant matters. For example, employee housing assignment, civil disputes between employees, disputes within employee's families, serving as go-between or intermediary in the marriages of men and women, etc. They both can make the employee feel some concern for the organization and mobilize the initiative of the masses as well as free the director from some daily trivial matters.


Chief Accountant
Finance Office
Administrative Logistics Office
Deputy Director for Personnel
Security Office
Laborer Personnel and Education Office
Quality Control Office
Director
Chief Engineer
Civilian Products Development Office
Military Products Technology Office
Scientific Research Goods and Materials Office
Deputy Director for Plan Administration
Technical Safety Office
Trial-Manufacture Production Office
Plan Administration Office
Institute Office

(Note: there are no further departments below office level to reduce levels)

Factories and enterprises generally form worker unions and have a wealth of work experience which can play an important role in enterprise construction and development. For a healthy research institute leadership management system, worker unions should also be established and the employee representative assembly system implemented. Under the concern of the institute party committee, to strengthen worker union construction, to study hard the work experience of enterprise worker unions, to combine it with the characteristic features of the research institute and to do a good job is very significant. This is a fundamental construction task for research institutes.

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CSO: 4008/2037

NATIONAL DEVELOPMENTS

OPEN DOOR POLICY FOR S&T INSTITUTES SUCCESSFUL

Beijing RENMIN RIBAO in Chinese 27 Jan 86 p 1

[Report by Ren Xinfa [0117 2946 4099] and Wang Yougong [3769 0645 1872]: "A Number of Research Institutes and Laboratories Affiliated with the Chinese Academy of Sciences Open to the Outside"]

[Text] Since 2 research institutes and 17 research laboratories affiliated with the Chinese Academy of Sciences opened to the outside beginning in August 1985, they have been warmly welcomed by both domestic and foreign scientists. Some famous scientists have praised the far ranging effect of this restructuring on the scientific mission and production in China.

In the process of implementing the resolution by the Central Committee regarding restructuring of the science and technology system, and in order to strengthen academic exchanges with colleges and universities and production sectors, the Chinese Academy of Sciences first selected the Institutes of Theoretical Physics and Mathematics because their equipment situations were rather good and their scholastic standards high, and opened them to the outside together with 17 research laboratories like the Structural Chemistry Laboratory of the Structure of Matter Research Institute in Fuzhou. These institutes and laboratories hired leading scholars from both within and outside the Academy; science workers who needed to come here to work had to first propose their topics in applications, and all those who have been passed by scholastic committees in the institutes and laboratories could be visiting researchers engaged in research and would be subsidized by the Science Fund. Now, there are already 113 scientists from outside the Academy and 17 foreign scientists engaged as directors or scholastic committee chairmen or committee members at these open institutes and laboratories. As of now, these institutes and laboratories have already received more than 600 applications and reports, and more than 360 topics have been approved by specialists, and there will be more than 600 scientists from outside the Academy who will come here one after the other to work, as well as more than 30 foreign scholars who will come for joint research.

Scientists have realized that this restructuring measure by the Chinese Academy of Sciences breaks up the barriers between sectors, and that it connects science work throughout the country and accelerates the opening of new channels for scholastic exchange and cooperation both domestic and foreign; the equipment and conditions for experiment at these institutes and laboratories have been unreservedly opened to science workers throughout the country so that to some degree they may avoid duplicate investment in research expenses, and that it will be beneficial in gathering outstanding talent to develop cooperative research; these units have given priority to opening to young scientists, which can speed up the training of high level science talent. Aside from this, scientists have also realized that this will also be beneficial to the cross influencing of different disciplines, which is of use to the development of rising new disciplines.

To better manage the institutes and laboratories that have been opened, the Chinese Academy of Sciences plans to establish complete management methods for research institutes and laboratories based on a summation of experiences from the first stage. To ensure the openness and mobility of these institutes and laboratories, they plan to better control fixed authorized complements, expand the numbers of visiting personnel, and plan to further expand the numbers of institutes and laboratories that are open to the outside. They will also hire laboratory and institute directors from throughout the nation.

12586
CSO: 4008/2067

NATIONAL DEVELOPMENTS

SURVEY OF SCIENCE RESEARCH INSTITUTES RELEASED

OW111158 Beijing XINHUA in English 1146 GMT 11 Mar 86

[Text] Beijing, March 11 (XINHUA)--Nearly all of China's 4,935 science and technology institutes were engaged in research for civilian purposes at the end of last year, according to a census released today.

Results of the survey, the first of its kind since the founding of new China in 1949, were announced by an official of the National Science and Technology Census.

The census began in November and was completed with the help of 30,000 people. Census workers found that more than 770,000 people work in the 4,690 civilian institutes, including 231,000 scientists and engineers and 121,000 technicians.

Last year the institutes earned 780 million yuan by developing technology for enterprises.

According to the census, China's 760 colleges and universities of science and engineering, agricultural and medical sciences have a technical force of 481,088 people, including 356,088 scientists and engineers.

The colleges and universities signed 7,077 contracts involving 126.4 million yuan with enterprises for technology development last year.

According to the census official, the census will help China to "modernize scientific management and provide the scientific information for making decisions on economic reforms."

The statistical standards used in the census, the official said, are equivalent to those of UNESCO.

Further reports are expected on China's scientific activities, research findings and research expenses based on the census data, the official said.

/6091
CSO: 4010/2011

CRITICISMS OF S&T SITUATION IN HIGHER INSTITUTIONS

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENTIOLOGY AND MANAGEMENT OF S&T] in Chinese No 11, 15 Nov 85 pp 33-35

[Article by Tao Xinliang [7118 9515 5328], Office of Science Research, Shanghai Industrial College: "Some Viewpoints on Science and Technology Development in Higher Institutions"]

[Text] I.

Higher institutions rely upon the comprehensive technical advantages of their full and complete curriculum; they rely upon the comprehensive advantages of having many teachers, graduate students, and undergraduates; they rely upon the comprehensive information advantages from their vantage point among developments in technology and as a site for the collection and dissemination of science information; they rely upon the comprehensive development advantages from both science and technology service and talent in cultivation. With intellectual investment as the primary form, with technical output and talent cultivation as the primary means, they have become a major force in the cause of science and technology development, and have become a very vigorous and important power in the technology markets. But as the markets have abruptly risen and quickly developed, scientific and technical development in the higher institutions has both had its own advantages and characteristics, and its new problems.

1. They are faced with a fierce and unprecedented competition.

The forceful opening of the technology markets is manifest in the daily bustle of both buyers and sellers. On the one hand, with the abrupt rise of township and town enterprises, the rapid development of small to medium factories, and the great advances in economic construction, the requirements of scientific and technical achievements were expanded, and buying capacity and potential for technology by buyers increased. On the other hand, there were also great changes in the conditions of the sellers. Currently, the main powers actively putting technical achievements out on the technology markets are not just the science research organizations and the higher institutions; there are also various hierarchical science and technology development companies and centers that are horizontally aligned and non-governmental. And there are science association systems and systems of trade unions and technical associations, and some medium to large, and even small, factories have been setting up their own technology development departments or third production structures, all of which have joined the ranks of sellers in the technology markets. Industrial and mining enterprises have relied upon their own mature production technologies and abundant economic capacities, and through the channels of joint operations of production, technology output, sending out the processing of components, and providing materials and markets, they have become more vital in the technology markets; science associations and technology associations use the advantages of their talent networks and generous economic remuneration to attract a number of technicians to engage in science and technology development; private science and technology development companies even more rely upon their flexible operations and adaptable economic means to make the most of the potential in technical talent from everywhere in society, including the higher institutions. With so many forces out there, science and technology development in the higher institutions is faced with a precipitous battle line and very fierce competition.

2. There is an unfortunate tendency for an outflow of intellect.

Science research and development at higher level institutions has in recent years been struck in succession by three great influences due to the fact that the economic treatment of teachers is uneven. These have been jokingly called "the three waves." First: the gap in economic remuneration between science and technology development projects and projects from planning has grown steadily wider, the former because of deductions in net income, as well as because the proportion of the deductions has continued to rise (for example, at this school it has gone from 4 percent to 10 percent, and then to 17 percent), and the latter because they have not charged a single cent, and although some schools have adopted methods to "supplement internal deficiencies with outside help," these have been totally inadequate measures. The gap between the respective economic treatments of these two things has reached the point where some teachers have begun to "treat internal planning lightly, while emphasizing external planning." This has weakened the reasonable structures in science research in the schools, as well as the technical reserves for science and technology development. The second "wave": the majority of teachers are members of learned societies affiliated with science associations at all levels, and some years ago the science association system raised the portion of economic income from science and technology development received by individuals to 30 percent, and some have covertly tried to make it even greater. The tendency for some teachers to "emphasize science associations and neglect teaching" has caused a number of science and technology development projects that could have been taken on by schools to be shifted to science and technology associations at various levels, with the result that although the schools produce intellectual and material resources, the science associations obtain the material benefit and success. The third "wave": an upsurge in having work in addition to one's job, which some have called "the second occupation." Higher institutions used to have strict limitations on the question of teachers having concurrent work, as for example where it was ruled that sparetime part-time jobs had to be approved by the unit, and a proportion of the income obtained thereby was taken by the unit to take care of neighbors, etc. The "Resolution Concerning Restructuring of the Science and Technology System" once again pointed out that "with the prerequisite that scientists and technicians complete their own work and not infringe on the technical rights and economic benefits of their unit, they may engage in technical work and consulting services in their spare time, the income from which will go to themselves; if the technical achievements and internal technical materials and equipment of the unit are used, that unit must agree to said use, and a portion of the income turned over to the unit." Macroscopically, this measure is undoubtedly beneficial to developing the enthusiasm of scientists and technicians, and to accelerating advances in science and technology and in the development of economic construction. But from the school's view of microscopic management, this will be difficult to get a precise hold on. Teachers do not have a strict schedule, and they cannot, as can industrial and mining enterprises and research organizations, put a clear boundary around 8 hours. Intellect and knowledge is a formless valuable product residing within the minds of teachers, and it would be very difficult to simply put on clear marks like "this belongs to the unit" and "this belongs to the individual," much less where there is no clear provision that sparetime part-time work be put on the unit's records. Therefore, the schools find it difficult to know and determine whether the individual has violated the technical rights and economic benefit of the unit, so how is it to know whether internal technical materials have been disclosed? Schools cannot understand this. This has led to the tendency where some teachers have "emphasized the part-time job, while neglecting their own."

"Emphasizing external planning over the internal"; "emphasizing science associations over the schools"; emphasizing the part-time job over the primary one," these three "waves" have resulted in a considerable portion of the intellect of schools being drained away.

3. There has not been a respect in fact corresponding to that in name.

Higher institutions are called one of the fifth route armies, but in fact have not received a sufficient amount of respect corresponding to that. It is, on the one hand, not like Chinese Academy of Sciences and local science academies, which can be supported by leading departments of all levels; nor is it like with research organizations in departments of the industrial and communications industries, that are supported by economics commissions, and in catering to factories have abundant financial resources for backup. When relevant leaders are dealing with large research development projects, what they think of first are the science academy system and affiliated research organizations; local industrial departments always think first that "rich waters should not flow to the houses of others," and confine their efforts to localities, taking care of research or development organizations run by the organization itself. It is always the case that only ungnawable hard bones and inedible chicken ribs and tails are turned over to the higher institutions.

Also, when some industrial departments import foreign advanced technology and equipment, they invariably neglect the high level capacity for assimilation and absorption possessed by higher institutions and science research organizations, and if they do not cast higher institutions to one side, they put them into secondary positions; higher institutions must cater to economic construction, but cannot "squeeze" into the higher echelons of scientific and technical development circles, into which advanced technology is absorbed and imported. They can only frustratingly chase after what is left, and cater to township and town enterprises with greater effort and take up work in the lower levels of science and technology development. If this goes on for a long time, it could create the following consequences: on the one hand, industrial departments will have lost the support of the scientific and technical capabilities of higher institutions, dragging down the process of absorbing imported technology and affecting the results from that absorption, even to the extent that they cannot give full play to the function of foreign advanced technology and equipment; sometimes, there is inappropriate repeated importation, which increases the expenditure of foreign exchange. On the other hand, higher institutions have therefore lost out on a valuable means of making contact with international advanced technology, and the level of science research cannot take advantage of an even greater boost, and sometimes it even happens that science research at higher institutions falls behind that of the level of technology already imported.

II.

How can we maintain and strengthen the capability for distillation of science and technology research at higher institutions?

1. Maintain the appropriate proportion of science and technology development funds, and increase encouragement economically. For the individual, there are four choices placed before the teachers at higher institutions: A. carry on in the capacity of the school, and when finished with a project, 14-17 percent of the net income should be deducted according to the particular provisions of each school as individual remuneration. B. Attach oneself to science associations, and deduct individual remunerations from 30 percent of net income according to science association provisions. C. Through the channels of private development companies, after completion, it is only necessary that they take 20-40 percent for management expenses, and the rest of the net income can be returned to individuals. D. Take on a spare time job directly with township and town enterprises or group units, the net income from which would nearly all go to the individual, or, as an alternative, he would receive a concurrent wage of the same amount. Among the four choices above, the deductions for the school itself are the least amount, but higher institutions still have the economic levers of increasing wages and promotions to maintain their momentum, attraction, and their distillation capacity. The proportion of money given to participants in technology development at higher institutions ought to be raised, or otherwise there will be a further increase in alienation, which would increase the tendency for intellect at higher institutions to flow away.

2. Provide for necessary procedures for managing concurrent jobs, and be more restrictive in discipline.

Seeing that teachers at higher institutions have no real 8-hour limitation, and that even including the quality of teaching and the amount of work done in research is a method that still lacks perfection and accuracy, therefore, when concurrent jobs are not approved by the units it can result in a few teachers "being on the job but their minds are elsewhere," a situation that cannot be controlled. It is recommended that provisions be made that sparetime part-time jobs by teachers at higher institutions be subject to approval by their units to more easily maintain the capacity for distillation of the science and technology development in higher institutions, and to reduce the outflow of intellect.

3. Enhance the self-building of higher institution science and technology development operations contingents.

Self-building of higher institution science and technology development operations contingents include two items. One is the improvement of the quality of the entire structure; the second is to arouse the enthusiasm of operations personnel.

Aside from deducting a certain percentage of economic income to encourage operations personnel in science and technology development, the prompt resolution of posts (academic rank) problems for operations personnel in science and technology development is an important measure for arousing the enthusiasm of those operations personnel. Operations personnel in science and technology development are just like people in research management and instruction management in that they are all professionals. Since we admit that management science is a large science, then why does management not share corresponding posts (academic rank)? We must change the erroneous conception that looks down on operations. Evaluation of the posts of specialized management workers ought to have different standards, should form a series of their own, ought to be based on the characteristics of specialist management workers themselves, and should be formulated as quickly as possible according to the relevant standards of other position series. This is also a necessary condition for science and technology development to have connections outside itself.

4. Coordinate well the science and technology research organizations of higher institutions with science research management organizations.

The original science research management organizations in higher institutions are an office level organizational system--the office of science research. In recent years, there have been two types of science and technology development organizations that have emerged, one being the earlier science and technology service department (science and technology development department), and the other kind is the recent science and technology development company. But the science and technology service department is subordinate to the office of science research, in other words, two names for just one group. We believe that: 1. there is a great deal of science and technology, procedures are complicated, and responsibilities are great. Therefore, structures should not be too small, and for the allotment of personnel there should be guarantees for a certain number of them and their quality. 2. Science and technology development companies and science and technology service departments are best managed together, for if the two are separate it will not be conducive to the overall planning of the school science and technology development, nor for overall arrangements. 3. Science research and science and technology development are two important links tightly forged together in a chain. Their relations must be strengthened, organically integrated, and they must never be severed.

12586
CSO: 4008/2044

SUGGESTIONS FOR REFORM OF COLLEGE S&T RESEARCH

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENTIOLOGY AND MANAGEMENT OF S&T] in Chinese No 11, 15 Nov 85 pp 32-36

[Article by Shuai Xiangzhi [1596 4161 1807], Office of Science Research, Shandong Shifan University: "Science in the Higher Institutions Is in Urgent Need of Reform"]

[Text] China's economic, science and technology [S&T], and education systems are currently faced with a new trend toward full-scale restructuring, and restructuring of the science and technology systems at higher institutions is also gradually developing. These reforms are of great significance to building China's four modernizations. Reforming scientific research at higher institutions is also an important aspect of this.

I. Reforming Science Research at Higher Institutions Will Suit New Trends in Economic Development

Since the founding of our nation, our higher institutions, and especially those affiliated with major academies, have made important contributions to economic and cultural construction, and some of the research achievements they have made have already been applied in actual production, and, what is more, have gained important economic and social results. However, because they have long been affected by "leftist" influences, the phenomenon in which the science research at higher institutions has been divorced from production has been all too serious. Just looking at the 1984 statistics from two major comprehensive colleges in Shandong alone, we can see that there was no direct relation between 60-70 percent of science research projects and production. Science research at higher institutions, and especially in applications and development research, has not received the attention it should have.

The CPC Central Committee pointed out long ago that "Higher institutions are both centers for education and are centers for science research, and they are am important front army for science research." The "two centers" points mainly to the social function of higher institutions, that is, the position and function of higher institutions in building toward modernization. To see the "two centers" as dealing with only teaching and research in higher institutions would be incomplete.

Currently, if science research at higher institutions is to concentrate on applications and development, then it must take as the goal of its topic selection the promotion of technical advancement, technical transformation, and the renewal and updating of products in industrial and mining enterprises, as well as importing, absorption, and assimilation. By joining higher institutions with factory and mining enterprises, we can make use of the methods of voluntary participation and mutual benefit and multiple formats: 1. to accept commissions from industry and factories through the channels of the technology markets and science and technology trade fairs, sign contracts for specialist projects, help research new products and new techniques, or by representing the development and provision of key equipment; 2. cooperatively undertake technical troubleshooting. Science and technology is a strongpoint of schools, and manufacturing and technique are the strongpoints of factory and mining enterprises. If the two cooperate, they can reduce research times and hasten the transformation of achievements into direct production forces; 3. establish joint research and production groups. With the schools taking on research, design, and experimentation, the factories can do processing and trial production, as well as provide a certain amount of research expenses to the schools. After the achievements have been appraised and are in batch production by the factories, the schools would deduct a percentage from the amount of annual sales (or annual profits). Working this way, we can quicken the research pace of schools, accelerate the transfer of achievements, and increase income; factories can also renew their products, improve their capacity for competition, and greatly increase their profits.

II. Implement a Research Topic Contract Responsibility System, Improve Benefits from Investment

By implementing a research topic contract responsibility system, we would organically combine the benefits for the state, units, and individuals with the responsibility, authority, and benefits of the research group and individuals. This would be beneficial to arousing the enthusiasm of the majority of teachers, would improve work efficiency and investment results, and would be a good method worth trying. But schools are not the same as factories and agricultural and specialist research institutes, so a research topic contract responsibility system cannot be implemented in one fell swoop. We must consider the characteristics of schools and the nature and source of responsibility for research topics, and adopt a corresponding research topic or responsibility contract system.

The most important sources of research topics for higher institutions include: directive planning by the National Science Commission, ministries in the State Council, regional science commissions, and relevant provincial departments, National Science Fund topics, and contractual commissions by factory and mining enterprises. In carrying out topic planning, because topic responsibility is clear for factory commissions, division of labor is specific, and rewards and punishment clear, tasking completion is somewhat better. But projects that are included in the planning of the state and regional science commissions are often not completed on time. Some schools favor seeking out directive research topics for the economic income to the particular unit. They have not given sufficient attention to planning arrangements, selection of personnel, and scientific and technical conditions, and to the necessary guarantees. On the contrary, they concentrate all their resources on those "immediately beneficial" topics that will increase income. The result of all this is that although they can provide new products and new techniques for factory and mining enterprises, as well as allow the researchers themselves to have more economic income, and teachers can obtain more reward money, this all adversely affects the completion of national science research planning. According to statistics, 16 higher institutions in Shandong ought to have completed 25 provincial science commission planning projects, but actually only finished 8, or 32 percent.

Everyone knows that nationally funded science research planning is determined by overall planning of the national economy, and is tasking that is concerned with the whole. If this kind of tasking is not completed, this will lead to national and social losses in technology, and sometimes these losses are extremely serious. Therefore, any unit implementing any kind of responsibility system must first assume national science tasking, and ensure that it is completed on time, with sufficient quality, and in sufficient quantity.

Based on the differing natures and sources of the topics that higher institutions take up, for directive planning an enforced planning responsibility contract system may be implemented; for projects commissioned by factories, a topic contract responsibility system may be used. But no matter what the form of the responsibility system, the responsibilities must be made clear, the times for completion and qualities should be clarified, and the rewards and punishments made clear. When topic tasking has been completed, research units and individuals may both receive a certain economic income.

If directive scientific research topics implement an enforced planning responsibility contract system, it can be done so that the school (office of scientific research) signs enforced planning contract documents with each department or institute. The contents of that contract would include: the research subjects, technical requirements, progress arrangements, personnel participating, required conditions (expenses, materials, instruments and equipment, and experimentation sites), and methods for reward and punishment. After the contracts have been signed, the topic group will formulate particular working plans, will place certain responsibilities on people, and will guarantee the on-time completion of the planned tasks. Based on the contract requirements, the school should allocate funds and materials promptly to the topic group. For that research tasking that is completed on time, and also that has outstanding economic or social benefits, or is at a higher academic standard, the topic group and individuals should be rewarded appropriately in accordance with award clauses. Award funds may be taken from a proportion of the research expenses for that project. For those projects not completed according to plan, and where there is no objective reason, this should be taken as the responsibility of those in the unit in charge and of the topic responsible persons, or a portion of the research expenses should be taken back, and they cannot apply for new projects for a certain time.

For topics that are commissions from factory and mining enterprises and that have been obtained through the channels of technology markets and science and technology trade fairs, responsibility contracts can be signed between the departments or institutes and the topic group or research laboratory. The contents of the contracts can be according to the needs of the factories, but should include clarification of responsibility, the division of labor, and punishments and rewards. We want to be responsible to society, and want to allow the achievements of research to truly produce economic results and to be worth the practical experience. To improve the returns on investment, schools should use project research funds or development funds that have been arranged within the school, or they can also implement bidding for topics and contracts for compensated usage.

III. Expand the Autonomy of Research Institutes and Laboratories

The phenomenon in higher institutions of "too secure, with stifling control" has been quite serious. When research units at higher level institutions have no authority over personnel or financial affairs, and there is a lack of vitality in economic construction, this sort of situation impedes the development of personnel intellect and creative abilities, nor is it a benefit to producing either achievements or talent. The author believes that reform should be undertaken in the following aspects:

1. There should be a certain amount of authority over personnel by research organizations. Research institutes would implement institute director responsibility systems, where institute directors have the authority to decide on facilities for organizations within the institute, and the authority to appoint or dismiss cadre. The deputy director can act in the name of the director, reporting to departments at higher levels for approval of appointments.

Within the research institute there should be freedom of organization for the topic groups, and there should also be gradual implementation of an employment system. The hiring system would chiefly operate within the institute, but based on the needs of the work, the institute could also go outside the institute to hire scientists, technicians, and technical workers, and can as well recruit graduate students and college students to participate in the research. As for those who are unemployed or are being sent away from the institute, there is the authority to make other arrangements and to aid in separation.

2. Research units would have the authority to use funds. We would change the troublesome method of the past in which spending even 1 yuan required signatures from the lab, the department (institute), and school. Use of science research funds can be done with three level control, namely, the school, the department (institute), and the lab or topic group. Anything at 2,000 yuan and below can be approved by responsible persons in the lab or by those responsible in the topic group; 5,000 and below can be approved by department (institute) the respective persons of responsibility; 10,000 and below can be approved by the office of science research (outlays above 10,000 yuan must be submitted to the responsible institute director). Science research development funds earned by the research institute may be arranged in general by the institute director for use primarily in laboratory construction and in arranging projects selected by the institute itself.

3. Science research organizations should have the vitality to cater to economic construction and the needs of society. Under the premise of ensuring completion of assigned science research tasking, we should permit departments (institutes) to integrate the research directions of a unit, fully using their own technical capabilities and conditions. On a contractual basis, commission other units for the tasks of research, experimentation, trial production, and technical processing. Also, on the basis of the compensated transfer of rights to technical achievements, sell small and medium trial products and develop technical servicing for the outside to generate economic income. Specialist research institutes should operate science research production models, both for study and for batch production, to gradually reduce the service fees that are provided by the state.

4. Those responsible for research institutes and laboratories should have the authority for rewards and punishment. Those responsible for research institutes and laboratories should establish a certain awards fund to reward outstanding accomplishments in research and in dissemination of achievements, to reward the greater contributions to economic construction and to society, and to reward scholastic innovations, and greater rewards for the most outstanding. Also, in the aspects of housing and living amenities, these accomplishments should be reported to relevant departments for appropriate consideration. There should be economic punishment for those who do not abide by distribution, and for those who cannot complete research tasking when there is no objective reason.

12586
CSO: 4008/2044

BRIEFS

ELECTRONICS PLANTS TRANSFERRED--Twenty five Shaanxi enterprises and units of the Ministry of Electronics Industry have been transferred to the jurisdiction of local authorities in the province. Leaders of the ministry and the provincial government held a takeover ceremony in Xian on 12 March. The units include the nos. 607, 702, 704, and 709 plants. They are being transferred to local jurisdiction in the province with effect from 1 February this year. The provincial government has decided that the Huang He Machine-Building Plant and the Hognhua Instruments and Meters Plant will be placed directly under Xian City. The other 23 units will be managed by the Provincial Electronics Industry Department for the time being. After a time, when conditions are ripe, they will be handed over to the jurisdiction of the towns where they are located. The Ministry of Electronics Industry and the provincial government have also agreed on specific views regarding the operational management and profit payment of these enterprises following their transfer. The ministry will provide macro guidance for the enterprises and develop them in a coordinated way. The Provincial Electronics Industry Department will continue to grasp reform, promote joint operations, and create conditions for transferring the enterprises to the jurisdiction of the cities where they are located. [Excerpts] [Xian Shaanxi Provincial Service in Mandarin 2300 GMT 12 Mar 86 HK] /12913

JAPANESE COMPUTER JOINT VENTURE--The Tianjin Economic and Technological Development Zone General Company and the (Kexi) Company Ltd. of Japan have decided to jointly finance and operate the Tianjin (Kexi) Company Ltd. The contract signing ceremony was held in Tianjin today. This jointly-financed enterprise will produce and develop computer peripheral equipment, computer accessary products, and plasma cutting and welding devices. A large part of the products will be exported to foreign countries, and the remainder will be supplied to meet domestic demands. Thanks to the rather perfect conditions for making investment and building plants in the development zone, this company will go into production within this year. [Text] [Tianjin City Service in Mandarin 1430 GMT 16 Jan 86 SK] /12913

JIANGSU COMPUTER APPLICATION--More computers are now being used in Jaingsu. The province boasts 4,700 computers, a twelvefold increase over 1983. The area of application of computers is also expanding. Now, computers are used in 1,500 fields, 10 times 1983. [Summary] [Nanjing Jiangsu Provincial Service in Mandarin 1100 GMT 20 Jan 86 OW] /12913

CONTROLLING ELECTRONICS IMPORTS--Li Peng, vice premier of the State Council recently: Beginning this year, China will carry out an appropriate protectionist policy on microcomputers and electronic parts produced by its electronics industry. Requirements for these items should be met mainly by domestic supplies if they can be produced in our country and if the quality of domestic products can satisfy needs. China has begun mass production of 8- and 16-bit microcomputers. Production of electronic parts has also attained a certain level. Therefore, in the days to come, if an item can be produced domestically and if the quality of the domestic product can be guaranteed, we should rely on domestic supplies and exercise appropriate control over imports. [Text] [Beijing in Mandarin to Taiwan 1500 GMT 27 Jan 86 OW] /12913

JIANGSU ELECTRONICS INDUSTRY--Jiangsu's Electronics Industry made much headway during the Sixth 5-Year Plan. The total output value in 1985 reached 5,135 million yuan, triple the record registered in 1980. The average annual growth rate of output value was 24.64 percent. In 1985 the industry contributed 817 million yuan to the state through the delivery of profits and payment of tax. This is 250 percent more than the contributions made in 1980. During this 5-year period, the industry completed 116 technological upgrading projects, including those using foreign technologies. Relatively big production capacities were established for such products as integrated circuits, computers, color TV sets, and radio cassette players. The quality of many products attained the international level for the 1970's and early 1980's [Summary] [Nanjing Jiangsu Provincial Service in Mandarin 1100 GMT 22 Feb 86 OW] /12913

NUMBER OF SCIENCE INSTITUTIONS--A recent national survey, the first of its kind in China, counted 4,935 institutions engaged in scientific research and technological development. In a press conference yesterday, an official from the State Science and Technology Commission said the national survey was aimed at determining the overall situation of science and technology in China. The survey, which began last November, involved 30,000 people. The official said it would help reform management methods in research institutes and technological development organizations. The survey found 770,000 people working in such institutes and organizations. Thirty per cent were scientists and engineers. Technicians made up 15 per cent of the total. According to the survey, China now has 760 colleges and universities involved in science, engineering, agriculture and medicine, with a combined staff of 481,088. Scientists and engineers total 356,088, and other technical personnel, 125,000. In 1985, there were 1,381 scientific research institutes and technical development organizations affiliated to colleges and universities, employing 28,768. [By Yang Xiaoping] [Text] [Beijing CHINA DAILY in English 12 Mar 86 p 1 HK] /6091

CSO: 4010/2011

APPLIED SCIENCES

STATE OF ACOUSTICS DEVELOPMENT BY YEAR 2000 DISCUSSED

Beijing WULI [PHYSICS] in Chinese Vol 14, No 9, Sep 85 pp 513-517, 534

[Article by Guan Dinghua [7070 1353 5478] of the Acoustics Research Institute, Chinese Academy of Sciences]

[Excerpt] III. The Present State of Domestic Acoustics Research.

Organized acoustics research began with the 20-year long-range plan of 1956. Since then China has worked in the various areas of architectural acoustics, noise control, ultrasonics, speech, atmospheric acoustics, hydroacoustics, electroacoustics, and musical acoustics. Some work has received national science prizes and some has won national discovery prizes and gained domestic and international recognition. Acoustics research in China is intimately tied to the national defense, the economy, and the people's livelihood; the broadening of its results has been swift, and it plays an important part in national construction.

In the area of hydroacoustics, we developed the theory of sound propagation in shallow water and the theory of deep sea convergence zones. We established sea floor acoustic characteristics research and research to apply acoustical methods toward study of ways to classify sea floor soil. We have launched study in the area of numerical forecasts of sound fields, normal wave filtration, propagation exchange relationships between normal waves and rays, remote reverberation, marine noise fields, boat noise, the relationship between gizhuang and internal waves in a sound field, absorption of sea sounds, reflections of sound by submerged objects as well as performing large quantities of hydroacoustic physical experiments. Work on shallow water sound fields has been rather creative, attracting domestic and international attention as well as capturing second prize in the national natural sciences awards.

We have developed high performance piezoelectric aggregates, sandwich polymer - piezoelectric ceramic composites as well as related absorption and damping materials. Many kinds of new types of transducers and corresponding transducer theories have also been developed.

In the area of hydroacoustic information processing, work has unfolded in polarity relations, digital multi--beams, pulse compression techniques, high speed FFT, high resolution spectral estimation as well as self adaptation techniques. Very great advances have also been made in large scale integrated circuits and the application of microcomputers to acoustical information processing.

We have developed horizontal and vertical fish detection devices, linear stratigraphic section instruments, various sounding devices, multi-beam sounding instruments, side looking sonar, acoustic release devices, sound wave instruments, square matrix under water holography systems, all of which have seen important application.

In the area of ultrasonics, we have produced research on flaw detection, including manufacture of flaw detecting transducers and flaw detection instruments, and photoelastic displays as well as theoretical calculations of acoustic scattering fields from defects. We have produced ultrasound microscopes and optical acoustic microscopes. We have developed work on acoustic sounding of subterranean rock, macrograin metallic flaw detection, and ultrasonic oil exploration. We have developed various model ultrasonic flaw detectors, pachymeters, flow meters, and anemometers.

In medical applications we developed various ultrasound diagnostic devices for use in diagnosis, Doppler effect blood-flow meters, and there has been rich experience obtained from the application of these instruments to clinical situations. There has also been much work on applications in ultrasonic treatment, ultrasonic pulverisation of calculus, etc.

Production and theoretical research has also been done on various surface wave devices. Such devices have attained wide application.

With the development of work on fluid kinetic whistle ultrasonic homogenization, pulverisation, and atomization, achievements have been made in the preparation of fuel additives and COM (Coal-oil mixture) so that there has been very high efficiency in conserving oil.

In the area of ultrasonic factory processes, many very good results have been attained in ultrasonic cleaning, processing, drilling, welding, tin plating, cold-drawing steel pipe, etc. Very good results have also been gained from ultrasonic irradiation processing food and Chinese medicinal herb seeds. Research has also been done on transducers and amplitude rods used to perform ultrasonic factory processing.

There have also been advances in research in the areas of high frequency phonons, molecular acoustics, and ultrasonics in liquid helium.

In the area of speech, work has been done on the analysis of Chinese, including vowels, consonants, tones, and resonances. Study has begun on language resolution and the characteristics of language perception.

Computers have begun to be used to study the synthesis of Chinese pronunication. A system for language differentiation has been completed using mini and microcomputers and its identification power is rather high for monosyllabic languages.

In the area of constructional acoustics and noise control, various designs for hall acoustics have been done. Research has begun on room sound fields and second order acoustic evaluation standards. Model experiments have been set up, successfully completing quite a few acoustic fidelity designs for halls, and research has designed many kinds of sound absorbing materials and structures, acoustic dampers, acoustic enclosures, and acoustic constructions. With regard to open-air noise, there has been profound research which won the third prize in the national natural sciences awards. Noise surveys and comprehensive management have been implemented at large industrial factories. For environmental noise in cities, systematic investigatory studies have been done and standards have been proposed.

In atmospheric acoustics and geoacoustics, we have studied the laws of sound propagation in the atmosphere, engaged in the monitoring of subsonic signals from typhoons and nuclear explosions, researched and developed highly sensitive geophones, and observed pre-earthquake seismic signals.

We have researched and produced various microphones, loudspeakers, earphones, hearing aids, vibration pick-ups, electroacoustic systems, acoustic instruments, and have established a standard for measurements in acoustics. Research has also been carried out in the areas of electroacoustic theory and stereophonic theory. Sound level meters and various acoustic instruments have also been produced through research and development.

IV. Prospects for Development.

Acoustics is a science with very high applicability. For this reason, the development of acoustical sciences cannot but receive greater influence from society's direct needs than do other branches of physics. Acoustical science's contribution to society are also more direct.

Acoustics and other sciences permeate each other. The swift development and major changes in related sciences (like microelectronics and microcomputers, with new models, functions, and materials) will induce strong echoes in acoustics, greatly speeding its development. Conversely, acoustics will also have a major influence on the new revolution in industrial techniques. Developments such as fifth generation computers, the information revolution, and robotics are inseparable from acoustics.

Acoustic research in China has a solid foundation. It also has the corresponding directing power and mainstay power which are the requirements for swift development. Acoustics is the "light industry" of physics. It can develop with only a minimum of necessary equipment. From these points it is clear that acoustics will develop energetically in the future.

We can imagine that before 1990 acoustics will further develop its branches which already have foundations as well as strengthen and fill in those branches which are weak or lacking. Strenuous increases in practical research, stressing the solution to the major key problems of information science, energy resources, environment, marine exploitation, and materials such as remote sensing, sonar, language and sound information processing, language machines, ultrasonic processing and energy conservation techniques, noise control, new model sound transmission sensory devices, ultrasonic electronics, and biomedical ultrasonics will diligently work to produce contributions to the national economy and defense. There will be continued emphasis on basic research, stress on following party theory, on the effects of ultrasonics on physical microstructures, the laws of ultrasonic transmission, reflection, and scattering, nonlinear acoustics, laws of sound transmission in the ocean, atmosphere, and through the earth, study of noise sources, and the action mechanism of sound in matter. Through diligent work to raise the standards of research every effort will be made so that by the end of this century the various major sub-disciplines in acoustics will attain international standards in research quality and areas of contribution as well as make a major contribution to the development of science in general. The general branch disciplines in acoustics will keep up with the international pace as well as satisfy domestic requirements.

From the viewpoint of science itself, we ought to stress development of ultrasonics, hydroacoustics, noise control, and speech and fill in the deficient areas of bioacoustics and psychoacoustics and correspondingly expand constructional acoustics, atmospheric acoustics, electronacoustics, and musical acoustics.

On the basic research foundation we will enhance research and development of instruments and equipment in the area of acoustics and strive in a short period to be able to meet domestic needs and attain competitive power in international markets.

Major Tasks:

(1) Noise Control: Henceforth we should emphasize airflow, vibration radiation, shock, and other noise production mechanisms, study methods of quality and fault [control] with sound source positioning and the use of noise and vibration monitoring equipment, study new methods and techniques to control sound, and study standards and legislation concerning environmental noise.

(2) Psychoacoustics and Bioacoustics: We ought to stress study of the auditory nervous system, study of the process of how the mechanism of a sensory cell generates a nerve pulse, achieve breakthroughs on how the aural nerve codes are transmitted to cerebral nerves, and the problems of cerebral nerve perception.

(3) Speech: With the development of computers and large scale integrated circuits, artificial synthesis of language and machine differentiation of language have advanced rapidly. The problems facing these areas at present are expansion of vocabulary and establishment of a system that differentiates continuous speech regardless of speaker. Synthetic speech also needs to be made more natural. Deeper study of the properties of language and of human perception of language is needed. Research work in the area of the characteristics of Chinese and the properties of the perception of Chinese ought to be completed by our scientists. This is a duty we cannot shirk. There will be even greater breakthroughs in efforts to use fifth generation

computers to implement human-machine language in the pursuit of dialogue and language transcription.

(4) Ultrasonics: Future study will concentrate on the laws of transmission, reflection, and scattering of ultra sound in solids. At the same time, we will develop various new flaw detection techniques (including acoustic emission techniques.) On the one hand, we want to resolve the defect detection [procedure] for different bodies (like coarse crystals and the human body.) On the other hand, we want to proceed with more microscopic observations (such as ultrasonic, optical-acoustic, and electron-phonon microscopic examination,) and also use computer assistance to get greater quantities of information, achieve automation, and obtain quantitatively determined and imaged results.

(5) Hypersonics: Focus here will be on study of the mutual effects of phonons and the microstructure of matter. This will provide a means to help understand the microscopic structure of matter.

(6) Ultrasonic Electronics: Development of new theory and new equipment will provide ways for processing of information in high frequency electronics.

(7) Applications of Ultrasonics to Matter: Emphasis will be on expanding areas of application, seeking out new applications, and effects in the area of energy conservation, such as ultrasonic preparation of COM fuel, oil additives, and liquefied coal, will result in achievements. With the disciplines of physics, chemistry, and biology, there will be close cooperative study of the mechanisms of ultrasonic applications including the mechanism of application to living matter.

(8) Atmospheric, Marine, and Terrestrial Sound Transmission and Applications: For these purposes we will study the laws of propagation in oceans, methods of using changes in sound waves for remote sensing of marine environments, such as marine acoustic tomographic techniques, and sea floor geomorphological acoustic telemetry. We will study remote measurement and close range high resolution soundings with imaging techniques for communication, orientation, dynamic orientation, and inlet reentry. There will be study of the corresponding techniques of code processing, transducing materials, and transducers. There will be an opening up of study of techniques of deep stratigraphic sensing, three dimensional seismic exploration, and petrographic methods.

(9) Electroacoustics: There will be increased research on new electroacoustic devices, such as silicon chips, polymer films, and optical microtransducers to form integrated sensors. Research on high quality laser recording, digital recording, reproduction, and transmission systems will take qualitative acoustic fidelity to new heights in order to fulfill the cultural needs of the people.

This report sought out the views of many domestic specialists and professors to whom we extend our thanks.

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12996/12913
CSO: 4008/18

HEALTH CARE IMPROVES FOR WOMEN, CHILDREN

OW081918 Beijing XINHUA in English 1911 GMT 8 Mar 86

[Text] Beijing, March 8 (XINHUA)--Mothers and children in China are receiving much better health care than a decade ago.

According to a report in today's "Health News", there are 3,055 mother and child care centers in the country, with a total of 30,000 beds. Together with the numerous mother and child care groups and rural doctors and specialized hospitals, it has formed a vast network to take care of women and children.

Staffed by more than 60,000 medical personnel and health workers, the centers and local hospitals have managed to reduce the death rate of Chinese expectant mothers and lying-in women from 150 per 10,000 in the early 1950s to the present five per 10,000, and that of perinatal babies to less than 24 per thousand, the paper said.

China attaches much importance to the health care of women above the age of 16 and children under 15, who account for two-thirds of China's total population.

The principle of putting prevention first is being implemented throughout the country. Health care and consulting services are extensively offered to women before and after marriage and, for expectant mothers, systematic health care and perinatal care are encouraged. Regular health checks, especially examination of cancers of the breast and uterine cervix, are carried out regularly in both cities and the countryside.

The paper said that efforts are being made in city hospitals to probe into the factors causing death of expectant mothers and perinatal babies in order to reduce the mortality rate even further.

The paper said that medical authorities are encouraging breast feeding and 21 provinces, municipalities and autonomous regions are conducting surveys and spreading the practice.

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CSO: 4010/1031

LIFE SCIENCES

BRIEFS

TIANJIN ANIMAL BREEDING--Tianjin, Jan 8 (XINHUA)--Three breeds of experimental mice up to international standards have been bred by Tianjin scientists. In the past, some Chinese medical research findings failed to get recognition in the past for using substandard experimental animals. The three breeds, named "Jinbai No 1", "Jinbai No 2" and "615", have been recognized by the International Committee on Standardized Genetic Nomenclature for mice. They were developed by the Tianjin Medical College and the Chinese Academy of Medical Sciences. China has imported seeds of laboratory animals from Britain, Japan and the United States since 1982, said Lu Yuezeng, director of the Academy's Medical Laboratory Animal Center. It has spent 15 million yuan building laboratory animal centers and breeding farms since 1983. The country now has six centers and seven farms. Major medical colleges, hospitals and institutes have their own laboratory animal departments, Lu Yuezeng said. The largest animal center, in Tianjin, produces an annual average of 3 million animals. [Text] [Beijing XINHUA in English 0749 GMT 8 Jan 86 OW] /6091

SHANGHAI INSTITUTE SYSTEM TO TEST CELLS--Shanghai, Feb 2 (XINHUA)--A microscopic system used to test and record the changes of cells of organisms in ultra-low temperatures has been developed at the Shanghai Mechanical Engineering Institute. The system, the world's sixth, can create an environment with a temperature down to minus 196°C, an institute spokesman said. It is fitted with precision video recorders and cameras to record the changes of the cells being tested. Shanghai scientists have used the system to study the destruction of cancerous cells and the preservation of human sperm, bone marrow cells, red blood cells and carp embryos. The results were "satisfactory", according to the institute spokesman. [Text] [Beijing XINHUA in English 0209 GMT 2 Feb 86 OW] /6091

HUNAN UNIT STUDIES CHROMOSOME DISEASES--Changsha, Feb 11 (XINHUA)--China has found that the rate of abnormal chromosomes in its new-born is 7.3 per thousand. Experts here said today the rate was determined by surveys of 3,415 babies by the research section on cell genetics at the Hunan Academy of Medical Sciences. They noted that the section has also discovered 48 "exceptional cases" of chromosome diseases which "have never been reported in the world before." The research section is now able to diagnose 95 types of chromosome syndromes and more than 300 kinds of abnormal chromosome diseases. It has offered consultation service on genetics to over 10,000 people in the past five years and has conducted chromosome examinations of 2,200. Its work avoided the birth of 109 babies with possible congenital abnormalities, the experts noted. The research section has also provided medical treatment for 119 patients with chromosome diseases, they added. [Text] [Beijing XINHUA in English 0638 GMT 11 Feb 86 OW] /6091

JIEFANGJUN BAO NOTES PLA HOSPITAL RESEARCH--Nanjing, Mar 8 (XINHUA)--Doctors here have discovered abnormal chromosomes which are thought to cause miscarriages and birth defects, according to the Liberation Army Daily. Abnormal karyotypes--the chromosomal constitution of the nucleus of a cell--cause 88.8 percent of abortions and birth defects, 16 times the rate when the chromosomes are normal, according to the experts. Doctors at the General Hospital of the Nanjing Military Area Command of the People's Liberation Army said if a woman is found to be a carrier of the abnormal chromosomes possible miscarriages can be avoided and, with careful medical guidance, it is possible for her to bear a healthy child. The hospital has opened a clinic to offer consultancy on this matter. [Text] [Beijing XINHUA in English 0748 GMT 8 Mar 86 OW] /6091

ELECTRONIC DEVICE HELPS PARALYSIS VICTIMS--Beijing, Mar 10 (XINHUA)--Chinese scientists have developed an electronic device to help patients suffering from hemiparesis (paralysis affecting one side of the body) to walk, according to the People's Railway Journal. A hospital attached to the Third Engineering Bureau of the Railway Ministry has successfully treated 80 patients with the new device, the journal reported. Developed by the Third Military Medical College based in Chongqing and the Ministry of Astronautics, the device is effective for 90 percent of hemiparesis cases caused by cerebral thrombus (vascular obstruction caused by a clot) or encephalemia (congestion of the brain) and some sequelae of infantile paralysis, according to clinical experiments. The device, looking like a small radio set, helps a patient to contract the extensor (muscle that extends a joint) of the leg and enable the patient to walk, according to doctors. At later stage, the device can aid a patient to correct the limb's direction, the paper reported. [Text] [Beijing XINHUA in English 0245 GMT 10 Mar 86 OW] /6091

CSO: 4010/1031

ENVIRONMENTAL QUALITY

GUANGXI CITY WORKS TO FIGHT POLLUTION

OW280916 Beijing XINHUA in English 0908 GMT 28 Feb 86

[Text] Nanning, February 28 (XINHUA)--Crowds of birds have returned to the shade trees of Guilin, one of China's most beautiful cities, as a result of anti-pollution efforts, a city official said today.

Guilin, in southern China's Guangxi Zhuang Autonomous Region, is noted for its scenery and crystal clear Lijiang River. But the city's rapid industrial development has polluted its air--causing, among other problems, the exodus of most of its birds more than five years ago.

To fight the pollution, and to protect Guilin's most attractive sights, China's central government has allocated 44 million yuan to city officials for local anti-pollution projects.

With the backing of the central government, city officials have shut down or renovated 69 factories and workplaces that were creating air and water pollution and equipped more than 200 industrial boilers with anti-pollution devices.

The city has protected underground water sources by diverting about 10 million cubic meters of industrial waste water through treatment channels.

By dredging silts, the water quality of the Lijiang, Taohua and Nanxi Rivers has been greatly improved.

The city has also planted 2.39 million trees and 53 flower beds and covered 130,000 square meters of land with lawns since 1981--and as a result many of the self-exiled birds have returned.

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CSO: 4010/1030

ENVIRONMENTAL QUALITY

HUNAN INTRODUCES RURAL ENVIRONMENTAL PROTECTION

OW080832 Beijing XINHUA in English 0652 GMT 8 Mar 86

[Text] Changsha, March 8 (XINHUA)--Hunan Province in central China has implemented protection programs to save trees, birds, frogs and snakes, and clean-up programs for cleaner water and air.

The province conducted a survey among 340,000 industrial enterprises in rural areas. Those guilty of polluting the air and water were required to control their emissions within a certain period of time.

While the majority have complied with the clean-up measures, 700 factories have been closed, according to the provincial bureau in charge of rural enterprises.

Building biogas fermentation pits is another effective measure for controlling pollution, since human excrement and animal droppings have been sterilized during the process of fermentation which provides additional fuel.

In Nanxian County, some villagers use the biogas to heat greenhouses for cultivating seedlings, and apply the residue from the biogas pit for fertilizing soil and gardens. The average income of those families reached 4,200 yuan last year, 50 percent more than in 1984.

About three million rural families, or one-third of the total in Hunan, use fuel-saving stoves, thus alleviating the shortage of firewood and reducing the felling of trees. Denudation was the main reason for soil erosion in this province as well as in other parts of China.

The provincial government has also designated a "bird-loving festival" and "bird-loving week" at the beginning of each year, when newspapers, radios and televisions disseminate knowledge about birds. The province has set up 23 nature reserves.

To protect frogs and snakes, the province has banned their sale at market. According to statistics from Changsha and Zhuzhou, 11,000 kilograms of live frogs and 4,000 snakes were confiscated at the markets and returned to the fields and mountains.

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CSO: 4010/1030

Solar Energy

PREPARATION OF SnO_2 FILM BY EVAPORATE-THERMAL DECOMPOSITION FROM AQUEOUS SOLUTION AND CHARACTERIZATIONS OF ITS OPTICAL AND ELECTRO-CONDUCTIVE PROPERTIES

Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Vol 6 No 4, Oct 85 pp 405-411

[English abstract of article by Li Chunhong [2621 2504 7703] and Wang Lan [3769 1526] of Changchun Institute of Applied Chemistry, Chinese Academy of Sciences]

[Text] In this paper a new preparation method for SnO_2 transparent electro-conductive film atmospheric evaporation-thermal decomposition from aqueous solution is presented. Some of its properties are characterized.

It is suggested that with this method it is simpler to prepare the transparent electro-conductive film of SnO_2 on surfaces of any shape when compared with a number of known methods. The results obtained with XDS, AES and ESCA indicate that an oxygen-defective SnO_{2-x} film with n-type semiconductor is formed during the processes just as in spray thermal decomposition.

The SnO_2 films possess properties of antireflection and transmission in visible range, and reflection in infrared range. In addition, the SnO_2 films inhibit the effects of thermal radiation. These functions are useful in solar energy development.

9717
CSO: 4009/36

FIRST EPITAXIAL FIRM BEGINS PRODUCTION

OW300413 Taipei CNA in English 0237 GMT 30 Dec 85

[Text] Taipei, Dec. 29 (CNA)--The first epitaxial manufacture in the Republic of China went into operation Saturday in the Hsinchu science-based industrial park in northern Taiwan.

A spokesman for the company, Episil Technologies Inc., said domestic manufacturers using epitaxials to produce semiconductor components will no longer depend on foreign suppliers because Episil's production can fully meet domestic requirements.

Epitaxial, an indispensable raw material in the manufacture of power transistors and integrated circuits, will become more and more important in manufacturing CMOS [complimentary metal oxide semiconductor] very large-scale integrated circuits, because it can solve the problem of latch-up, he said.

Previously, the spokesman said, ROC manufacturers have to depend on foreign exporters to supply epitaxials and, therefore, the shipments of this material are unstable and usually take a long time. It is also inconvenient for domestic importers to identify its specifications and to offer after-sale services.

With Episil fully supplying domestic requirements, domestic manufacturers may lower their production costs by reducing stocks and shorten their research and development cycles, he added.

Episil is scheduled to produce 20,000 to 30,000 pieces of epitaxial monthly at the first stage and will increase its production capacity later on.

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CSO: 4010/1032

CABINET APPROVES VLSI PROJECT; TASK FORCE NAMED

OW161213 Taipei CNA in English 1022 GMT 16 Jan 86

[Text] Taipei, Jan. 16 (CNA)--The Executive Yuan Thursday approved a proposal to set up a very large-scale integrated circuit [VLSI] plant in the country.

Premier Yu Kuo-hwa also appointed a five-member task force to take charge of preparatory work for the proposed plant. The five are Economics Minister Lee Ta-hai; Finance Minister Robert Chien; Chao Yao-tung, chairman of the Council for Economic Planning and Development; Chen Li-an, chairman of the National Science Council; and Chang Chung-mo, director of the Industrial Technology Research Institute.

Premier Yu said that the project runs a risk. "But in order to promote the technological development and industrial upgrading," he stressed, "we should take the risk."

According to preliminary estimates, the proposed VLSI plant will cost about U.S. dollar 207 million. Of the amount, 30 percent, or U.S. dollar 62 million, will be loans from banking institutions. Government funds will account for 48.3 percent of the total equity; foreign capital, 27.6 percent; and the remaining 24.1 percent will be from local private investors.

All the capital must pay in four installments; 40 percent of their shares each in 1986 and 1987 and 10 percent each in 1988 and 1989. The Bank of Communications will collaborate with other local banks to supply the loans.

In picking a foreign partner, the cabinet will give priority to the one who can help promote development of the local electronic industry.

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EXECUTIVE YUAN APPROVES VLSI JOINT VENTURE

OW180323 Taipei CNA in English 0239 GMT 18 Jan 86

[Text] Taipei, Jan. 18 (CNA)--The Executive Yuan has approved the very-large-scale-integrated circuit (VLSI) project proposed by the Ministry of Economic Affairs (MOEA) that enters the government into a U.S. dollars 207 million joint venture with private firms, informed sources said.

In approving the project, Premier Yu Kuo-hwa said that despite the large risks involved, the government will accept the challenge of the investment and lead the nation's industrial transformation.

The premier also appointed five ranking officials to an ad hoc committee that will supervise the project's implementation.

The appointees are: Chao Yao-tung, chairman of the Council for Economic Planning and Development (CEPD), Chen Li-an, chairman of the National Science Council, Economics Minister T.H. Lee, Finance Minister Robert Chien, and Morris Chang, president of the Industrial Technology Research Institute.

The VLSI project, as proposed by the MOEA, requires a total capital of U.S. dollars 207 million for setting up a manufacturing company. Of this, equity capital will amount to U.S. dollars 145 million, and loans, U.S. dollars 62 million. Of the equity capital, 48.3 percent will come from the government and the balance from foreign and local private investors.

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SYNCHROTRON CENTER PLANNED FOR NORTHERN TAIWAN

OW030325 Taipei CNA in English 0256 GMT 3 Feb 86

[Text] Taipei, Feb. 1 (CNA)--The first radioactive synchrotron center in the Republic of China will soon be built near the Hsinchu science-based industrial park, some 100 kilometers south of Taipei, an official with the Executive Yuan said Saturday.

The official, who preferred anonymity, said the decision to build the synchrotron center was made in a meeting of the Synchrotron Research Center Supervisory Board presided over by Dr. Yuan Chia-liu, chairman of the board.

Also present at Saturday's meeting were K.T. Li, minister without portfolio, Y.S. Tsiang, national policy advisor to the president, Yen Chen-hsing, chairman of the Atomic Energy Council, Chen Li-an, chairman of the National Science Council, and Dr. Samuel Ting, a Chinese-American Nobel Prize winner in physics.

Participants in the meeting also decided to immediately begin the design for the office building for the center.

Before the new building is completed, the staff of the board will work temporarily at the precision equipment center in the science park in Hsinchu, the official said.

The official did not disclose who will be in charge of the construction project, saying only that several French experts have expressed interest in this job.

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